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SUBJECT: Annual Summary of Hydrologic Data for the White Oak Creek Watershed

TO: T. E. Myrick, Building 3001, MS-029

FROM: C. B. Sherwood, Building 3504, MS-317
D. M. Borders, Building 1505, MS-036

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UCN-2383K
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Annual Summary of Hydrologic Data for the White Oak Creek Watershed

INTRODUCTION

Purpose and Scope

This is the first of a series of annual reports designed to summarize the hydrologic data collected in the White Oak Creek (WOC) watershed (Fig. 1), which drains the Oak Ridge National Laboratory (ORNL). The purpose of the report is to document the hydrologic data collected in the ongoing ORNL environmental studies and monitoring programs to (1) aid in characterizing the quantity and quality of the water in the flow system, (2) aid in remedial action planning, and (3) aid in providing long-term data availability and quality assurance.

The report will summarize the available dynamic hydrologic data collected during the year along with information collected on the surface and subsurface flow systems, which affect the quantity or quality of surface and groundwater.

The report was prepared as part of the ORNL Remedial Action Program (RAP), which was established to provide comprehensive environmental management of all inactive contaminated sites at the Laboratory. Most of the data included in the report have been compiled, formatted, and entered into the RAP data base management system (Voorhees et al. 1986).

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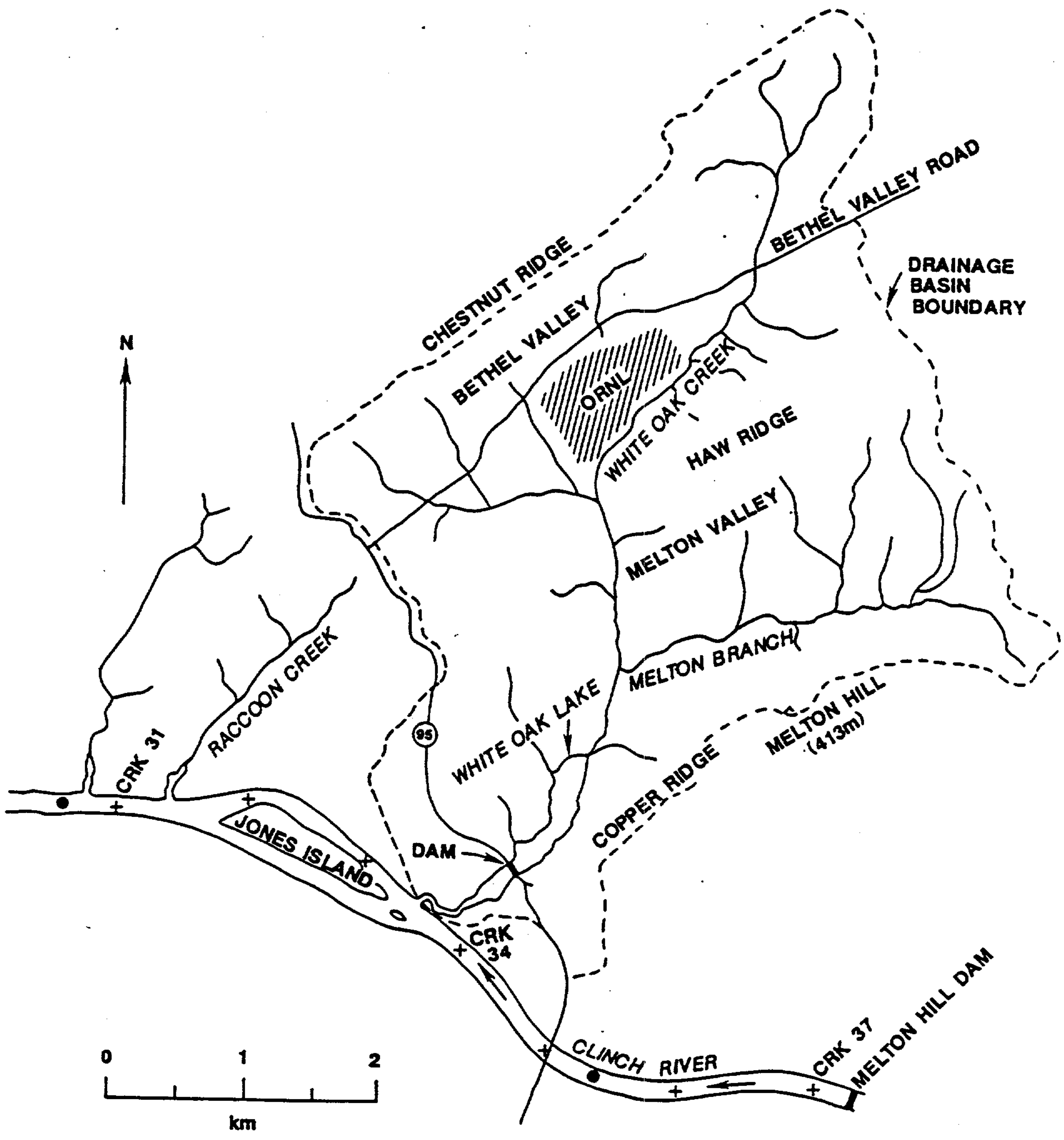

Fig. 1. White Oak Creek Watershed.

This report represents one of the hydrogeologic characterization needs outlined in TM-10062 (Sherwood and Loar, 1986), which was prepared to summarize the available information on the hydrogeologic and ecologic characteristics of the White Oak Creek (WOC) flow system, and the nature and quantity of contaminants released to and from the system. The earlier report also identified further characterization activities needed in the ORNL Remedial Action Program to meet state and federal environmental regulations.

Background

The Oak Ridge National Laboratory (ORNL) is located in the WOC watershed, which drains a 16.8 sq. km (6.5 sq. mile) area tributary to the Clinch River (Fig. 1). In addition to natural drainage, WOC has received treated and untreated effluents (nonradioactive and radioactive) from Laboratory activities as well as leachates from subsurface waste storage areas (Fig. 2) since the early 1940s. The waters of WOC are impounded by White Oak Dam (WOD), which was constructed 1.0 km (0.6) miles upstream from the Clinch River in 1943 to form White Oak Lake (WOL) to act as a holding pond for ORNL waste effluents. Sediments within the WOC flow system have sorbed chemical and radioactive contaminants and have subsequently accumulated in the WOC flood plain and WOL sediments. Oakes et al (1982) estimated that since 1943, some 5×10^6 ft^3 of contaminated sediment collected in the lake bed, which contains an estimated 650 Ci of radioactivity, primarily Co-60, Sr-90, and Cs-137. Water in the lake contains measurable quantities of dissolved

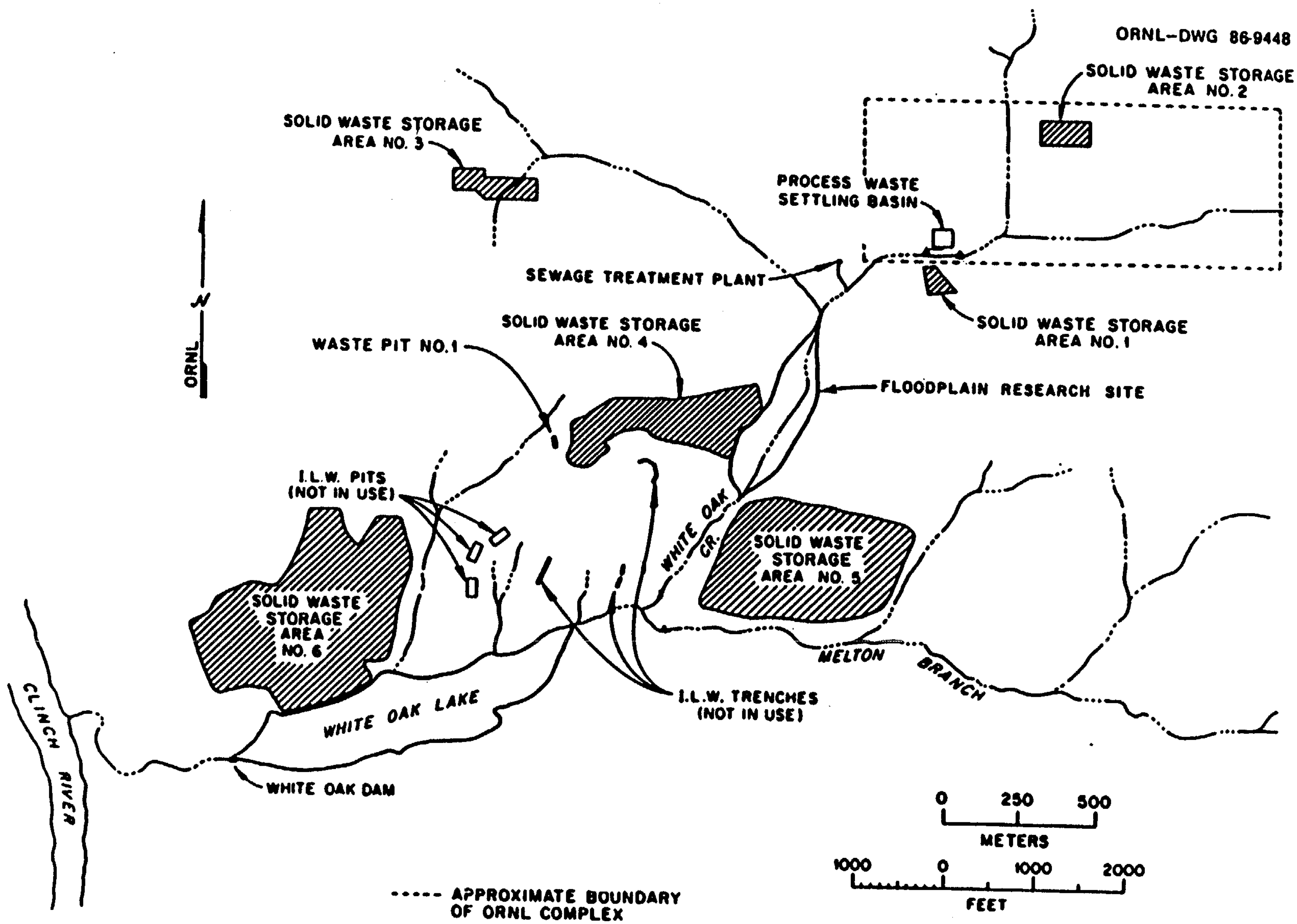

Fig. 2. Schematic of the White Oak Creek watershed showing potential sources of contaminants.

H-3 and Sr-90, which are released through the monitoring station at WOD. During periods of heavy rainfall, both dissolved radioactive nuclides and resuspended contaminated sediment are released from the lake to the Clinch River. WOD is the final point of release of waterborne contaminants from ORNL.

As a federally-owned facility, ORNL is required to comply with federal, state, and local environmental regulations regarding waste management (solid, liquid, and gaseous). In response to these requirements, ORNL established a Remedial Action Program (RAP) in 1985 to provide comprehensive management of areas where past research, development, and waste management activities have been conducted and have resulted in residual contamination of facilities or the environment. For planning and management purposes, the ORNL RAP has subdivided ORNL and the immediate surrounding areas into Waste Area Groupings (WAGs)--areas that can be treated as single hydrogeologic units for characterization and remedial action activities (Fig. 3). The lower WOC flood plain has been designated WAG 2. The lower WOC flood plain is downstream from the ORNL Main Plant, WAG 1, and is partly bounded by other potential contaminant sources in WAGs 4-9. These WAGS, which represent contaminant inputs to WAG 2, will be characterized and upgraded under separate Remedial Action Program activities.

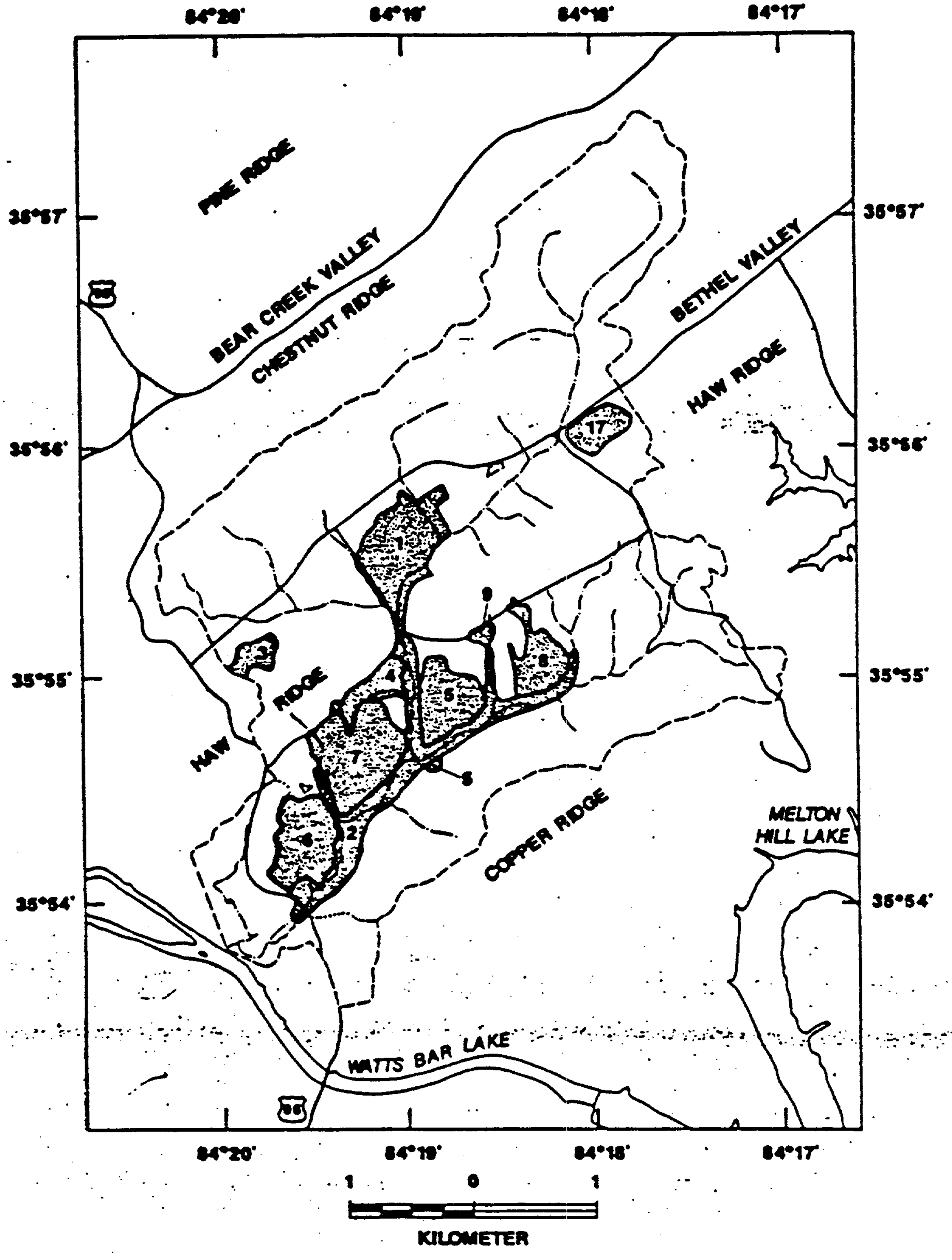

Fig. 3. Waste area groupings (WAGs) in the White Oak Creek Watershed.

SITE DESCRIPTION

White Oak Creek rises from springs on the southwest slopes of Chestnut Ridge and, with its tributaries, drains much of Bethel and Melton Valleys (which include ORNL) to the Clinch River (Fig. 1). The waters of WOC are impounded by White Oak Dam (WOD) at WOC's intersection with White Wing Road (State Route 95) 1 km (0.6 mile) upstream from the Clinch River. The drainage areas upstream from the Clinch River and WOD are approximately 16.8 km^2 (6.5 $mile^2$) and 15.5 km^2 (6.0 $mile^2$), respectively (Martin Marietta Energy Systems, Inc., 1985).

White Oak Dam is a low-head structure with a normal lake elevation of 227.1 m (745 ft) only 0.9 m (3 ft) above full-pool elevation, which is 226.2 m (742 ft) in the Clinch River. Flow from WOL discharges through a weir and a concrete-box culvert to the lower reach of WOC. Modifications were made to the flow system at the dam in 1983 to increase the flood discharge capacity to 56.6 m^3/s (2000 ft^3/s), the estimated flow for a 100-year storm in the WOC watershed.

Water levels and flow in WOC below the dam are largely controlled by the operation of Melton Hill Dam 3.7 km (2.3 miles) upstream on the Clinch River and Watts Bar Dam, which forms Watts Bar Reservoir about 94 km (58.8 miles) downstream on the Tennessee River. When Watts Bar Reservoir is near full pool (approximately April to October), backwater from the Clinch River creates an embayment in WOC below the dam.

Controlled releases of ORNL treated and untreated effluents to WOC include those from the Process Waste Treatment Plant, the Sewage Treatment Plant, and a variety of process waste holding ponds scattered throughout the ORNL complex. The WOC flow system also receives effluent from nonpoint sources, the Solid Waste Storage Areas (SWSAs) and LLW pits and trenches, through both surface and groundwater flow (Fig. 2). Sediments within the watershed have sorbed chemical and radioactive contaminants and have accumulated in floodplain and lake bed areas. Under high-flow conditions, these sediments can be carried over the dam to the Clinch River. For a short time during early ORNL operations (1943-1944), liquid wastes discharged to WOC were held up in an intermediate pond formed by an earthen dam near the present SWSA 4 site. During this period, contaminated sediments accumulated within the basin area. In late 1944, this earthen dam failed and the intermediate pond was drained; however, most contaminated sediments were left in the flood plain area.

The four major geologic units which underlie the WOC drainage basin are from northwest to southeast, the Knox Group of Cambrian and Ordovician age, the Chickamauga Limestone of Ordovician age, and the Rome Formation and the Conasauga Group of Cambrian age. All formations strike northeast at about 56° and dip southeast at angles commonly between 30° and 40°.

The Knox Group underlies much of Chestnut and Copper Ridges, which bound the drainage basin to the north and south. The Knox is mainly composed of cherty dolomite in which sinkholes and caverns have developed.

The Chickamauga Limestone underlies Bethel Valley, including the ORNL Main Plant area, and SWSAs 1, 2, and 3 (Fig. 2). It is composed predominantly of limestone, although shales, siltstones, and bedded chert comprise a significant minor part of the formation. The strata generally are thin to medium bedded. Fractures and solution openings occur between the beds of the Chickamauga, but the openings are smaller than in the Knox.

The Rome Formation is exposed along Haw Ridge. The formation generally consists of soft argillaceous shale containing occasional thin siltstone layers less than 1 in. thick.

The Conasauga Group, commonly referred to as the Conasauga shale, underlies Melton Valley, including SWSAs 4, 5, and 6, and the pits and trenches area, which was formerly used for liquid waste disposal (Fig. 2). The general sequence through the Conasauga formation is gradational, from shale at its base to impure bedded limestone at its top. WOL and the lower part of WOC rest on limestone or shaly limestone of the Conasauga Group.

Groundwater occurs in all four formations that underlie the WOC basin. The dolomite of the Knox Group on Chestnut Ridge and the Chickamauga Limestone underlying Bethel Valley apparently are the principal water bearing units because they discharge larger amounts of water, per unit drainage area, to the streams than the other geologic units. The Rome Formation on Haw Ridge and the Conasauga Group underlying Bethel Valley discharge smaller quantities of water to the streams. Water occurs in the weathered rock of all units.

Since WOL was created in 1943, a number of studies have been undertaken to determine contaminant sources, quantities of contaminants released and retained in the lake, and the geology and hydrogeology of WOC/WOL. Table 1 presents a summary of some of the more important studies since 1945. In some instances, the studies referenced in Table 1 represent summaries of the information developed; individual investigators have reported greater detail on their efforts in other reports and papers.

HYDROLOGIC DATA

The collection of hydrologic data in the White Oak Creek watershed began with facility planning studies in the early 1940s and developed into the long-term program of environmental research studies and monitoring activities required to cope with the Laboratory's unique waste management needs.

The hydrologic data available for the report period were derived largely from ongoing studies of the ORNL remedial action program and from the continuing monitoring program conducted by the ORNL Environmental Monitoring and Compliance Department (EMC). Much of the current monitoring is associated with the National Pollution Discharge Elimination System (NPDES) permit for ORNL operations. Information on hydrologic data available in the RAP data base management system and data summaries for selected stations are given in the following sections.

Table 1. Summary of significant studies conducted in WOC/WOL 1943-1986

Year	References	Areas of investigation
1945-46	Cheka and Morgan (1947)	First reported data on sediments in WOL.
1950	Setter and Kochtitzky (1950)	Drainage areas and estimates of WOL capacity.
1948-52	Abee (1953)	Sediments in WOL.
1950-53	Krumholz (1954a,b,c)	Initial fish population and radioecological studies.
1956-58	Auerbach et al. (1959)	68 shallow soil samples taken, soil mass estimated. Total ^{90}Sr content estimated. Agricultural plots established in former WOL bed.
1958	Lee and Auerbach (1959)	Radiation field above the drained WOL.
1961	Lomenick et al. (1961)	Sediments in WOL. Vertical and lateral distribution studied. Sediment discharge estimates in drained WOL.
1962	Lomenick et al. (1962)	^{106}Ru distribution in WOL sediments. Total ^{106}Ru content estimated.
1962	Lomenick et al. (1963)	Variation in radionuclide content of water and sediment with flow. 250 cores taken in lake bed. Measured thickness of sediments and radionuclide content. Cs inventory established.
1964	McMaster and Richardson (1964)	Ten sediment ranges. Vertical distribution of ^{106}Ru, ^{137}Cs, and ^{60}Co measured.
1965	Lomenick and Gardiner (1965)	Additional measurements of the vertical distribution of radionuclides in sediments. Vertical distribution of ^{137}Cs studied.
1969	Kolehmainen and Nelson (1969)	WOL radioecology studies.
1970	Tamura et al. (1970)	Sediment sampling in embayment.
1972	Blaylock et al. (1972)	Update of earlier assessment of radionuclides in WOL sediments.
1976	Webster (1976)	Hydrogeology of WOC/WOL.
1977	Blaylock and Frank (1979)	Tritium in sediments of WOL.
1978	Edgar (1978)	Flood discharge estimates.
1979	Cerling and Spalding (1981)	Analysis of streambed gravels for ^{60}Co, ^{90}Sr, and ^{137}Cs.
1979-80	Loar et al. (1981a)	Comprehensive study of the aquatic ecology of WOC/WOL and the CR above and below the WOC embayment.
1982	Oakes et al. (1982a)	History of WOL, sediments, water quality.
1983	MMES (1984)[1]	Environmental Monitoring Report. WOL sediment and water analyses.
1984	MMES (1985)[1]	Environmental Monitoring Report. WOL sediment and water analyses.
1985	Cerling (personal communication)	Update of 1979 streambed gravels survey.
1985	Synoptic ecological survey	Update results of the 1979-80 comprehensive survey.
1986	Blaylock et al. (In press)	Compilation of information on the radioecology of WOL.

[1]Martin Marietta Energy Systems

Source: Sherwood and Loar 1986

Climate

Data on precipitation, temperature, humidity, and wind speed and direction are available for various periods of record at several stations in the vicinity of the watershed (Table 2). The closest long-term meterological data (1947 to date) is available from the National Oceanic and Atmospheric Administration monitoring station in Oak Ridge about 15.4 km (9.6 miles) north of the center of the watershed.

Meteorological stations for which data are available in the RAP data base management system are shown in Fig. 4. Site descriptions and information on data collection methodology are shown in Table 3.

Precipitation is probably the most important climatic factor because it establishes the quantity and variations in runoff and streamflow as well as the replenishment to the groundwater system. Monthly precipitation for the period May 1986-April 1987 at seven sites in the watershed and the Oak Ridge station and the long-term mean at Oak Ridge are shown in Table 4. Daily precipitation at these sites is shown in Appendix A.

Surface Water

Data on surface water flow and quality are collected at a number of sites in the White Oak Creek flow system as part of the EMC monitoring and compliance program associated with the NPDES permit, evaluations by the Interim Waste Operations group, and in studies of the Remedial Action Program. Some periodic water quality data are also collected as part of the Biological Monitoring and Assessment Program which is required by the NPDES permit.

Table 2. Meterological stations in the vicinity of White Oak Creek Watershed[a].

Station description	Location	Period of record	Measurements
Knoxville[b]	McGhee Tyson Airport	1942-present	Precipitation
		1942-present	Wind
		1942-present	Temperature
		1942-present	Temp. gradient
		1942-present	Humidity
Oak Ridge	City	1947-present	Precipitation
		1947-1979	Wind
		1947-present	Temperature
		1947-present	Temp. gradient
ORNL Towers A & B	ORNL	1982-present	Precipitation
		1982-present	Wind
		1982-present	Temperature
		1982-present	Temp. gradient
ORNL Tower C	ORNL	1982-present	Precipitation
		1982-present	Wind
		1982-present	Temperature
		1982-present	Temp. gradient
		1982-present	Humidity
		1982-present	Solar radiation
USGS[c]	SWSA-5	1975-present	Precipitation[d]
USGS[c]	SWSA-6	1976-present	Precipitation[d]
ETF	SWSA-6	1980-present	Precipitation[d]
EPICOR[e]	SWSA-6	1985-present	Precipitation
		1985-present	Wind
		1985-present	Temperature
		1985-present	Humidity
SW7	Proposed SWSA 7	1984-present	Precipitation
Bldg. 1505	ORNL	1984-present	Solar radiation

[a]At various times, meteorological measurements have been made at the Y-12 plant, K-25, an early X-10 station, and the tower shielding facility (ORO-99).

[b]Measurements also exist for the period 1871 till the station was moved to McGhee-Tyson.

[c]U.S. Geological Survey.

[d]Precipitation gauges are not equipped to measure snowfall.

[e]Ion exchange resin leaching site.

Source: Boegly et al. 1985.

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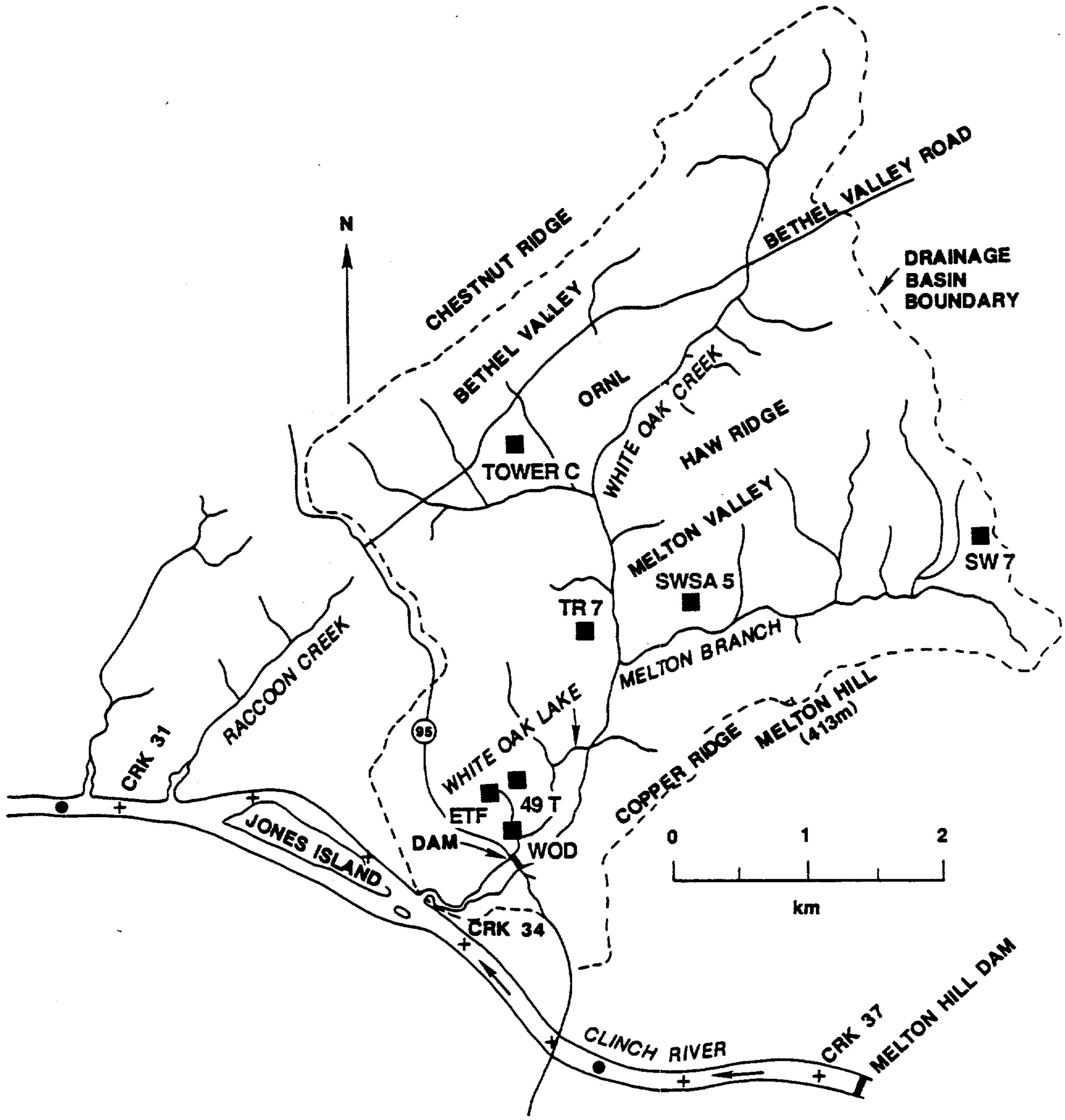


Fig. 4. Meteorological sites in the White Oak Creek Watershed for which data is included in the RAP data base management system.

Table 3. Site descriptions for precipitation stations in White Oak Creek watershed.

OBS	SITE IDENTIFICATION	LOCATION NAME	TYPE OF GAGE	FREQUENCY OF DATA COLLECTION	SMALLEST UNIT OF MEAS FOR GAGE
1	ATDL NOAA/ATDL	Oak Ridge	Belfort Weigh & Stick Ga.	Hourly	0.01"
2	DEM34	White Oak Dam	Belfort Heated Tip Bucket	10 Minutes	0.01"
3	DEM99	Met Tower C	MRI Tipping Bucket	10 Minutes	0.01"
4	ETF	SWSA 6	Belfort Weighing	Daily	0.01"
5	GS5	USGS/ SWSA 5	Elect. Tipping Bucket		
6	49T	49 Trench Site	Belfort Weighing	Daily	0.01"
7	SW7	Center 7 Creek Watershed	Belfort Weighing	Daily	0.01"

Table 4. Monthly precipication by station in the White Oak Creek Watershed and at Oak Ridge (precipitation in mm).

Month	49 Trench	SWSA 6 (ETF)	SWSA 5	Tower C[1]	TR 7	SW 7	White Oak Dam	ATDL Actual	ATDL Normal
MAY 1986	73.40	76.90	65.78	****	66.33	65.41	76.46	69.59	89.41
JUNE 1986	27.20	26.00	34.03	****	33.29	43.19	20.31	36.82	100.08
JULY 1986	71.20	68.10	89.41	****	87.50	94.10	9.90	72.14	144.02
AUGUST 1986	128.00	124.40	129.03	****	130.07	97.81	184.40	72.14	97.79
SEPTEMBER 1986	58.80	64.80	63.75	****	60.59	71.24	22.86	119.38	84.84
OCTOBER 1986	122.00	122.50	119.63	****	120.26	120.63	120.63	114.54	69.09
NOVEMBER 1986	108.80	108.70	107.70	****	110.97	106.98	99.57	93.22	102.87
DECEMBER 1986	120.41	129.72	118.62	****	115.53	120.34	116.32	135.12	136.14
JANUARY 1987	120.73	124.86	124.21	35.56	118.45	122.26	118.11	123.69	133.35
FEBRUARY 1987	128.77	128.36	125.73	114.30	125.16	126.12	125.97	143.25	133.10
MARCH 1987	75.20	75.35	61.97	58.42	64.99	62.47	75.17	61.98	138.43
APRIL 1987	69.07	75.21	62.73	50.80	73.40	70.39	72.90	69.86	106.93
TOTAL (MM)	1103.58	1124.90	1102.59	259.08	1106.54	1100.94	1042.60	1111.73	1336.05
TOTAL (IN)	43.45	44.29	43.41	10.20	43.56	43.34	41.05	43.77	52.60

[1] ORNL MET Tower precipitation data not available before January, 1987.

Discharge

Daily streamflow data collected at 6 sites (Fig. 5) in the White Oak Creek system are available in the RAP data base management system. Three sites, White Oak Dam, White Oak Creek above Melton Branch, and Melton Branch are operated by the Environmental Monitoring and Compliance Division as part of the NPDES permit requirements and 3 sites are operated by the U.S. Geological Survey (USGS) as part of RAP studies to isolate individual contributions of upstream hydrologic units or for forecast modeling purposes. Three Additional USGS sites have been established where stage data are being collected, but flow measurements are presently inadequate to establish the rating curves required to convert this stage data to streamflow. Streamflows at these 3 sites will be calculated for the entire period of record when satisfactory rating curves have been established.

Electronic signals transmitted from the EMC stations are monitored by near real-time data systems of the EMC Data Acquisition System (DAS). Because of the complexity and importance of the EMC sites the following detailed station descriptions have been included.

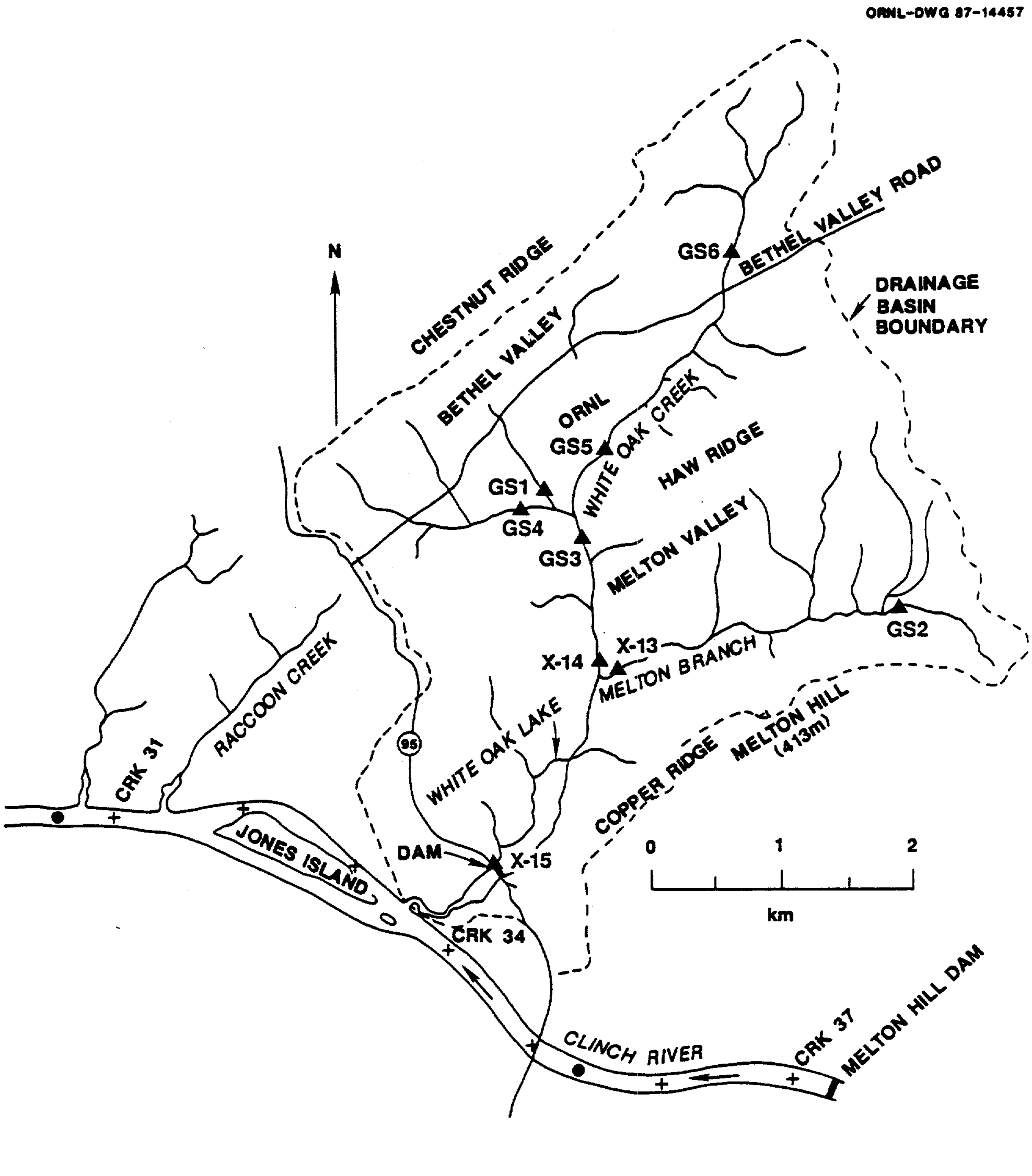


Fig. 5. Stream gaging sites in White Oak Creek and its tributaries.

1. White Oak Dam (WOD). Station is located at the lower end of WOL where WOC flows under State Highway 95, 0.6 miles above the confluence with the Clinch River. The station is housed in a metal building beside the channel. Water behind the dam flows through two gates (each 18 feet wide), through a 40-ft-wide channel, across a full-width V-shaped flume, then across a 3-ft-wide Cipoletti weir (1.33 feet high). The notch elevations on the flume and weir are 744.0 feet and 743.5 feet, respectively. Maximum lake elevation with the gates closed is 750 feet above sea level. Crest elevation of the earthen dam is approximately 756 feet.

The station contains three ultrasonic flow meters in stilling wells linked to the flow channel by piezometer tubes. Flow meters record high flow range (max. 2000 cfs) and medium flow range (max. 200 cfs) by measuring hydraulic head behind the flume. These two units use the same stilling well. The low flow range meter (max. 15 cfs) measures hydraulic head in the pool behind the cipoletti weir. A fourth ultrasonic unit measures tailwater below the low flow weir to provide an alarm in the event that the Clinch River floods high enough to flow back into WOL.

2. White Oak Creek (WOC). Station is located on WOC above the confluence with Melton Branch. The station is housed in a metal building beside the channel. Water flows into a pool upstream from the station, through twin 100° V-notch weirs (2.5 feet high), and then through a 36-ft-wide channel across a broad-crested flume. The elevations of the top of the weir, the weir notches and the broad-crested flume are 755.31 feet, 752.81 feet, and 748.75 feet, respectively.

   The station contains two ultrasonic flow meters in stilling wells linked to the flow channel by piezometer tubes. The high flow meter records high flow range (max. 1200 cfs) by measuring hydraulic head behind the flume. The low flow range meter (max. 60 cfs) measures hydraulic head in the pool behind the V-notch weirs. The station also contains one ultrasonic unit to measure tailwater.

3. Melton Branch (MB). Station is located on MB above the confluence with WOC. The station is housed in a metal building beside the channel. Water flows into a pool upstream from the station retained by a sill, through a 120-degree V-notch weir (2.25 feet high), and then through a 24-ft-wide channel across a broad-crested flume. The elevations of the top of the weir, the weir notch and the broad-crested flume are 755.60 feet, 753.35 feet, and 751.43 feet, respectively.

The station contains two ultrasonic flow meters in stilling wells linked to the flow channel by piezometric tubes. The high flow meter records high flow range (max. 600 cfs) by measuring hydraulic head behind the flume. The low flow range meter (max. 34.7 cfs) measures hydraulic head in the pool behind the V-notch weir. The station also contains one ultrasonic unit to measure tailwater.

The following is a station description summary for the USGS flow measurement sites:

1. Upper White Oak Creek (WOC). Station is on White Oak Creek, just north of the point where WOC crosses White Oak Avenue, near Building 6000. Instrumentation includes a float-type gage and stilling well in an instrument shelter on the right bank of the stream.

2. Parshall Flume on WOC. Station is located at the existing MS-2 flume on WOC. Instrumentation includes digital recorder and small float system mounted at the upstream side of the concrete structure containing the flume, near the left bank.

3. First Creek. Station is located at the new compound flume installed on First Creek, between Burial Ground Road and the confluence with the Northwest Tributary. Instrumentation includes a digital stage-height recorder mounted on the existing stilling well.

4. Northwest Tributary. Station is located at the existing concrete and stainless steel weir which is used as the control. Instrumentation includes a bubbler unit for measuring stage height and a digital recorder.

5. White Oak Creek at the 7500 Bridge. Station is located on the existing structure. The instrumentation transmit data via the satellite telemetry system in use by the USGS. The data are available in near real-time, but will also be processed to produce printed summaries.

6. Melton Branch near Melton Hill. Station is located in the upper reach of Melton Branch near study center 7. Instrumentation includes a float-type gage mounted on a stilling well and equipped with a digital stage height recorder.

Monthly flow summaries for the 6 sites for which data are available in the RAP data management system are shown in Table 5. Daily flow data for these sites are shown in Appendix A.

Water Quality

Surface water quality is monitored by EMC for both radiological and chemical constituents at a number of sites in the White Oak Creek flow system as part of the NPDES program. Additional water quality data have been collected at selected sites as part of the BMAP activities and other RAP studies. These in-stream sites are shown in Fig. 6.

Table 5. Monthly discharge at selected sites in the White Oak Creek flow system[1]

(flow rates in cubic feet per second)

			GS1	GS2	GS3	X14	X13	X15
1986.	MAY	MEAN	***	0.06	7.01	6.46	0.82	7.77
		MIN	***	0.01	5.80	4.98	0.48	5.62
		MAX	***	0.38	12.00	10.35	.2.21	12.10
	JUNE	MEAN	***	0.01	6.73	7.31	0.63	8.01
		MIN	***	0.00	5.80	6.39	0.32	6.79
		MAX	***	0.09	9.20	10.35	1.72	11.53
	JULY	MEAN	***	0.02	7.15	7.47	0.60	7.96
		MIN	***	0.00	6.10	6.31	0.12	6.71
		MAX	***	0.20	11.00	12.38	1.72	13.52
	AUGUST	MEAN	***	0.00	7.22	7.43	0.52	7.68
		MIN	***	0.00	6.10	5.79	0.19	0.11
		MAX	***	0.00	11.00	15.94	1.62	28.52
	SEPTEMBER	MEAN	***	0.00	7.03	7.39	0.54	7.98
		MIN	***	0.00	6.10	5.66	0.23	5.85
		MAX	***	0.01	14.00	17.47	2.00	19.46
	OCTOBER	MEAN	***	0.05	7.80	8.15	0.80	10.24
		MIN	***	0.00	5.57	4.63	0.32	5.52
		MAX	***	0.95	24.72	16.21	2.54	18.78
	NOVEMBER	MEAN	***	0.33	8.71	9.08	1.46	11.40
		MIN	***	0.01	6.42	6.00	0.46	6.44
		MAX	***	1.77	17.66	17.11	5.35	24.28
	DECEMBER	MEAN	***	1.00	11.46	12.11	3.65	15.69
		MIN	***	0.10	5.72	5.82	0.82	7.40
		MAX	***	13.20	59.15	58.98	37.69	118.62
1987.	JANUARY	MEAN	***	1.36	12.28	13.21	8.31	18.52
		MIN	***	0.07	5.73	4.89	0.26	6.27
		MAX	***	23.22	83.43	46.54	44.79	82.79
	FEBRUARY	MEAN	1.35	1.27	13.07	12.80	5.37	16.43
		MIN	0.48	0.17	6.95	6.27	0.26	7.43
		MAX	5.35	9.12	49.44	45.89	24.52	69.07
	MARCH	MEAN	1.06	0.75	10.81	12.10	3.59	16.25
		MIN	0.63	0.31	7.12	6.36	1.39	8.97
		MAX	3.67	3.50	32.73	45.89	19.86	69.07
	APRIL	MEAN	1.01	0.82	10.62	10.60	2.86	13.10
		MIN	0.52	0.12	7.06	6.10	0.67	7.40
		MAX	2.44	4.06	23.25	20.36	10.04	27.14

[1]GS1 = FIRST CREEK
GS2 = MELTON BRANCH NEAR MELTON HILL
GS3 = WHITE OAK CREEK BELOW MELTON VALLEY DRIVE
X14 = WHITE OAK CREEK
X13 = MELTON BRANCH
X15 = WHITE OAK DAM

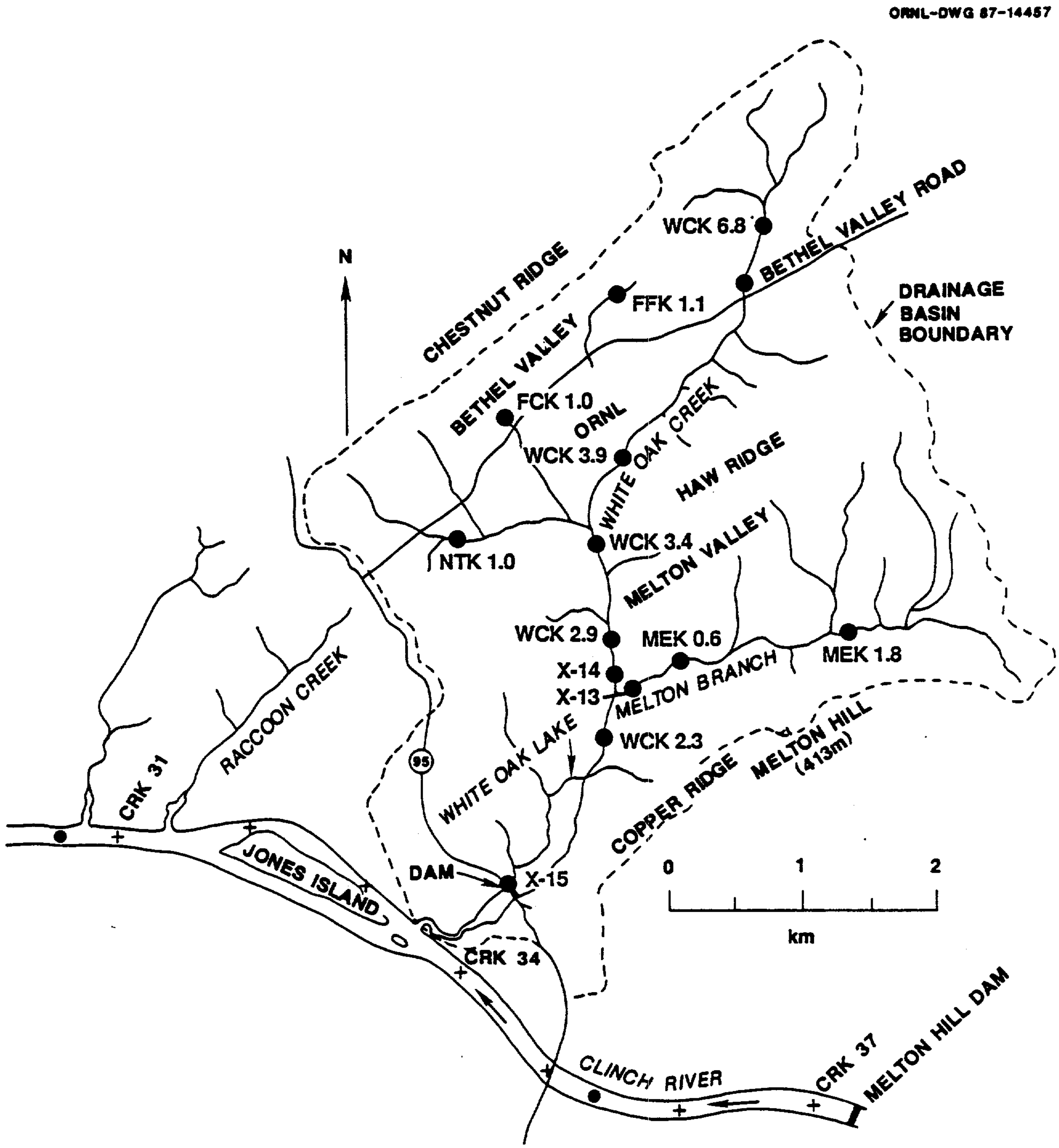


Fig. 6. Surface water quality monitoring or sampling sites in White Oak Creek and its tributaries.

Summaries of radiological data for the in-stream monitoring sites are reported in the EMC quarterly environmental data reports (EMC 1986a-d, 1987a, b). The results of analyses of selected chemical and radiological constituents in samples collected in the WOC system are also included in the annual summary of environmental data for the Oak Ridge Reservation (Environmental Safety and Health 1986). Additional analytical results for chemical and physical parameters at the EMC sites and at a number of upstream reference sites are included in the BMAP annual report for 1986 (Loar et al. 1987). Tables 6 and 7 show median concentrations of selected physical and chemical parameters in water samples from the three primary EMC in-stream sites for different periods in 1986. Table 8 shows the results of BMAP discrete water quality sampling for chemical and physical parameters at 10 sites in WOC and its tributaries during September 1986.

Monthly discharge of selected radionuclides at the primary EMC in-stream sites is calculated from flow and concentration values and presented in the quarterly environmental data reports. The discharge of ^{137}Cs, total radiological strontium, and ^{3}H at WOC (X14), MB (X13), and WOD (X15) for the period May 1986-April 1987 is shown in Figs. 7-9. The data in Fig. 9 show an apparent inconsistency during the winter months, where the discharge of tritium at the basin outlet is shown as only about one half that of an upstream tributary. These results have identified a problem with the procedure used for compositing flow-proportional samples from high, medium, and low ranges of flow rates. Steps are being taken to resolve this matter at present.

Table 6. **Median concentration (range in parentheses) of 12 water quality parameters that were monitored in Melton Branch (X13), White Oak Creek (X14), and at White Oak Dam (X15) under the old and new (after April 1, 1986) NPDES permits. Tabular values are mg/L unless noted otherwise; NS = Not sampled (after Loar et al. 1987). Source: ORNL Department of Environmental Management.**

	Sample type[a]	Sampling frequency[b]	MB(X13)[c] 1986	WCK(X14)[d] 1986	WOD(X15) 1986
Ammonia	1	M/M	0.06	0.07	0.08
BOD, 5-d	1	W/M	<5 (<5-13)	<5 (<5-10)	<5 (<5-11)
COD	1	W/O	8.5 (<5-66)	2.5 (<1-21)	NS
Conductivity (uS/cm)	2	W/M	455 (100-1000)	365 (200-480)	390 (200-410)
Chromium (ug/L)	1	W/M	<10 (<10-12)	<10 (<4-38)	<24 (<20-4)
Dissolved oxygen	2	D/W	8.0 (4.0-12.9)	7.8 (5.0-12.3)	7.4 (2.0-15.0)
Oil and grease	2	M/W	2 (<2-69)	<2 (<2-107)	2 (<2-27)
pH	2	D/M	8.0[e] (7.1-8.9)	7.7[e] (7.0-8.6)	7.9[e] (7.2-8.5)
Suspended Solids	1	W/M	<5 (<5-85)	<5 (<5-87)	5 (<5-52)
Temperature (°C)	2	D/M	9[e] (0-17)	11[e] (6-16)	9[e] (2-18)
Turbidity (JTU)[f]	2	W/M	10 (0-82)	11 (0-240)	78 (35-240)

[a] 1=24-h composite; 2=grab.

[b] Numerator is frequency under old NPDES permit (January 1, 1985-March 31, 1986) and denominator is frequency under new NPDES permit (April 1-December 31, 1986); D=daily; W=weekly; M=monthly; 0=discontinued.

[c] Average background concentrations were 159 mg/L for total dissolved solids and 0.5 ug/L for chromium based on grab samples collected weekly between April 1979 and January 1980 in upper Melton Branch near MEK 1.8 (Boyle et al. 1982, Fig. 3.11 and Table 4.16).

[d] Average background concentrations above ORNL nar WCK 6.3 were 101 mg/L for total dissolved solids and 0.5 ug/L for chromium (see footnote 'c' in Boyle et al. 1982, Fig. 3.11 and Table 4.15); near WCK 6.8, average pH and conductivity were 7.8 and 209 uS/cm, respectively (McMaster 1967, Table 11).

[e] January through March only.

[f] Jackson Turbidity Unit.

Table 7. Median concentration (range in parentheses) of 20 water quality parameters that were monitored in Melton Branch (X13), White Oak Creek (X14), and at White Oak Dam (X15), April 1-December 31, 1986[a]. Tabular values represent 24-h composite samples unless noted otherwise; NS = Not sampled (Loar et al. 1987). Source: ORNL Department of Environmental Management.

Parameter	Concentration (ug/L, unless noted otherwise)			
	Above ORNL[b,c]	MB(X13)	WCK(X14)	WOD(X15)
Aluminum (mg/L)	0.06[d]	<0.12 (<0.02–0.84)	<0.12(<0.02–0.41)	0.20(<0.12–1.30)
Arsenic[e]	NS	<60(<10–<60)	<60(<10–<60)	<60(<10–<60)
Cadmium	0.12	<2(all <2)	<2 (all <2)	<2 (all <2)
Chlorine, residual (mg/L)[f,g]	NS	0.00(0.00–0.16)	0.00(all 0.00)	0.00(0.00–0.10)
Chloroform[g]	NS	<1.6(0–3.0)	6.8(0–8.0)	2.8(0–3.4)
Copper	0.9	<12(<2–<12)[e]	<12(<2–13)	<12(<2–15)
Fluoride (mg/L)	0.1[d]	2.2(<1.0–25.0)	1.0(<1.0–1.0)	1.0(<1.0–1.0)
Iron	65	178(50–650)	94(22–490)	285(86–1300)
Lead	0.9	<4(<4–4)	<4(<4–5)	<4(<4–5)
Manganese	12	94(31–450)	29(23–43)	82(28–1500)
Mercury	0.02	<0.05(<0.05–0.10)	0.10(<0.05–0.20)	<0.05(<0.05–0.10)
Nickel[e]	4	<36(<6–<36)	<36(<6–<36)	<36(<6–<36)
Nitrate (mg/L)	0.3[d]	<5.0(<2.0–14.0)	<5.0(<2.0–5.3)	<5.0(<2.0–5.0)
Organic carbon, total (mg/L)[g]	NS	4.0(1.8–5.0)	3.0(2.2–4.6)	3.6(1.9–5.7)
Phenols, total[g]	2	<1(<1–2)	<1(<1–3)	NS
Phosphorus (mg/L)	0.02	0.88(0.11–1.70)	0.63(0.13–0.80)	0.36(0.17–0.76)
Silver[e]	NS	<5(<5–<30)	<25(all <25)	<25(all <25)
Sulfate (mg/L)	2.7[d]	306(21–1065)	60(24–299)	62(25–305)
Trichloroethylene[g]	NS	<1.9(0.0–<5.0)	<1.9(0.0–<10.0)	<1.9(0.0–<10.0)
Zinc	3	41(15–150)	32(27–40)	14(<10–61)

[a]Most parameters were also sampled in January prior to issuance of the new NPDES permit.
[b]North of Bethel Valley Road near WCK 6.3.
[c]Values represent the mean concentration of grab samples collected weekly between April 1979 and January 1980; n = 37 (see Boyle et al. 1982, Sect. 3.2.3.2 and Table 4.15). Similar sampling was conducted in upper Melton Branch near MBK 1.8 over the same time period, and average concentrations were the same as those for upper WOC above ORNL except iron (130 µg/L), mercury (0.05 µg/L), manganese (32 µg/L), and nickel (5 µg/L) (Boyle et al. 1982, Table 4.16).
[d]North of Bethel Valley Road near WCK 6.8; values represent the mean concentration of samples collected in 1961-1964; n = 6 (McMaster 1967, Table 11).
[e]All values were below the detection limits.
[f]Sampled weekly.
[g]Grab sample.

Table 8. Discrete water quality monitoring results for September 1986. NA = Not available for September (Loar et al. 1987).

	WCK[a] 6.8	WCK 3.9	WCK 3.4	WCK 2.9	WCK 2.3	MEK[a,b] 1.8	MEK 0.6	FCK[a] 1.0	FFK[a] 1.1	NTK[a,b] 1.0
pH	8.19	8.12	8.03	8.05	8.06	7.9	7.75	8.23	7.84	7.89
Alkalinity (meq/L)	3.03	2.5	2.3	2.28	2.2	2.24	0.99	3.14	2.98	4.56
Conductivity (umhos/cm)	266	361	334	342	391	226	878	259	269	390
Hardness (mg/L as $CaCO_3$)	166	180	172	166	194	138	460	162	142	190
Total Phosphorus (µg P/L)	19.1	595.1	673.3	680.2	748.1	20.6	1568	43	27.8	15
Sol. Unreactive P (µg P/L)	15.1	69.6	40.2	90.2	31	12.1	99.6	28.6	11.8	10.9
Sol. Reactive P (µg P/L)	0.7	127.4	275.6	292.8	350	7.3	858.9	3.5	7.7	1.9
$NO_3^- + NO_2^-$ (mg N/L)	0.05	0.58	1.29	1.4	1.34	0.01	1.97	0.04	0.15	0.02
Ammonia-N (µg N/L)	24	25.3	26.5	22.8	26.5	2.9	31.5	8.4	12.7	2.4
Diss. Organic C (mg C/L)	2.24	3.54	3.34	3.36	3.11	3.21	3.49	0.96	0.76	2.24
Total Susp. Solids (mg/L)	3.3	1.7	2.9	2.5	3.2	5.5	1.2	2.8	2.3	5.7
Temperature (°C)	17.1	22.5	21.6	21.5	21.8	10.4	25.7	18	14.2	12.5
Soluble Ca (mg/L)	12	44	40	44	47	NA	140	13	12	NA
Soluble Cu (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	NA	<0.2	<0.2	<0.2	NA
Soluble Cr (mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	NA	<0.04	<0.04	<0.04	NA
Soluble Cd (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	NA	<0.005	<0.005	<0.005	NA
Soluble Fe (mg/L)	<0.03	<0.03	<0.03	<0.03	<0.03	NA	<0.03	<0.03	<0.03	NA
Soluble Mg (mg/L)	17	13	11	11	13	NA	31	16	16	NA
Soluble Mn (mg/L)	<0.005	0.019	0.018	0.015	0.023	NA	0.052	<0.005	<0.005	NA
Soluble Na (mg/L)	0.63	9.5	12	13	15	NA	28	0.98	1.6	NA
Soluble Pb (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	NA	<0.2	<0.2	<0.2	NA
Soluble Si (mg/L)	3.9	3	2.5	2.6	2.9	NA	7.1	4	3.5	NA
Soluble Zn (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	NA	<0.02	<0.02	<0.02	NA

a Upstream reference sites: WCK 6.8 and NTK 1.0 are shown in Fig. 6; site MEK 1.8 is located approximately 50 m below the USGS gage shown on Fig. 6; FCK 1.0 is located above the small pond on upper First Creek, approximately 200 m above site FCK 0.8 (Fig. 6); and site FFK 1.1 is located on upper Fifth Creek about 100 m above site FFK 1.0 on Fig. 6.

b Site dry in September; data shown are for November.

FIG. 7. Monthly discharge of cesium-137 in surface waters

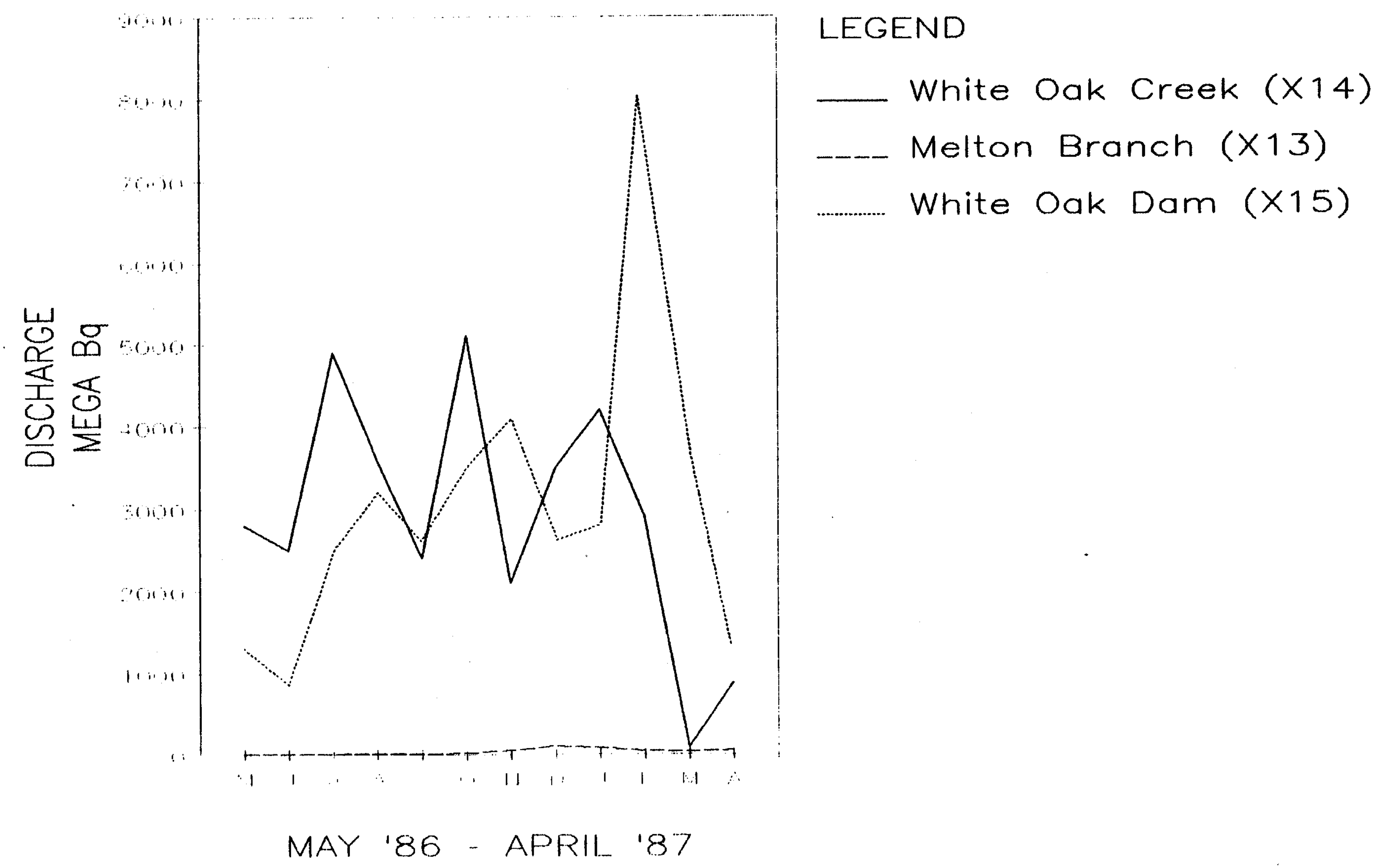


FIG. 8. Monthly discharge of strontium* in surface waters

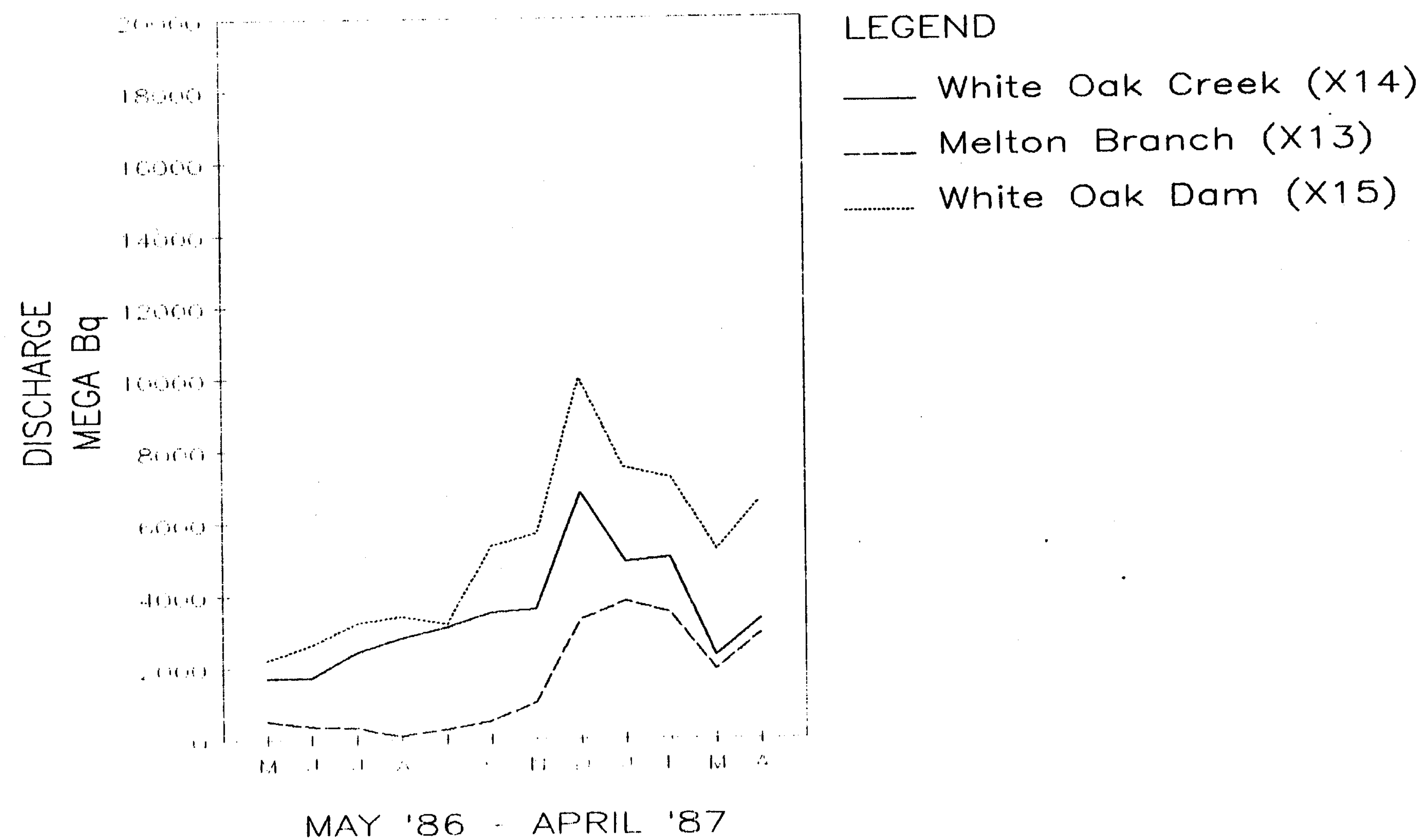
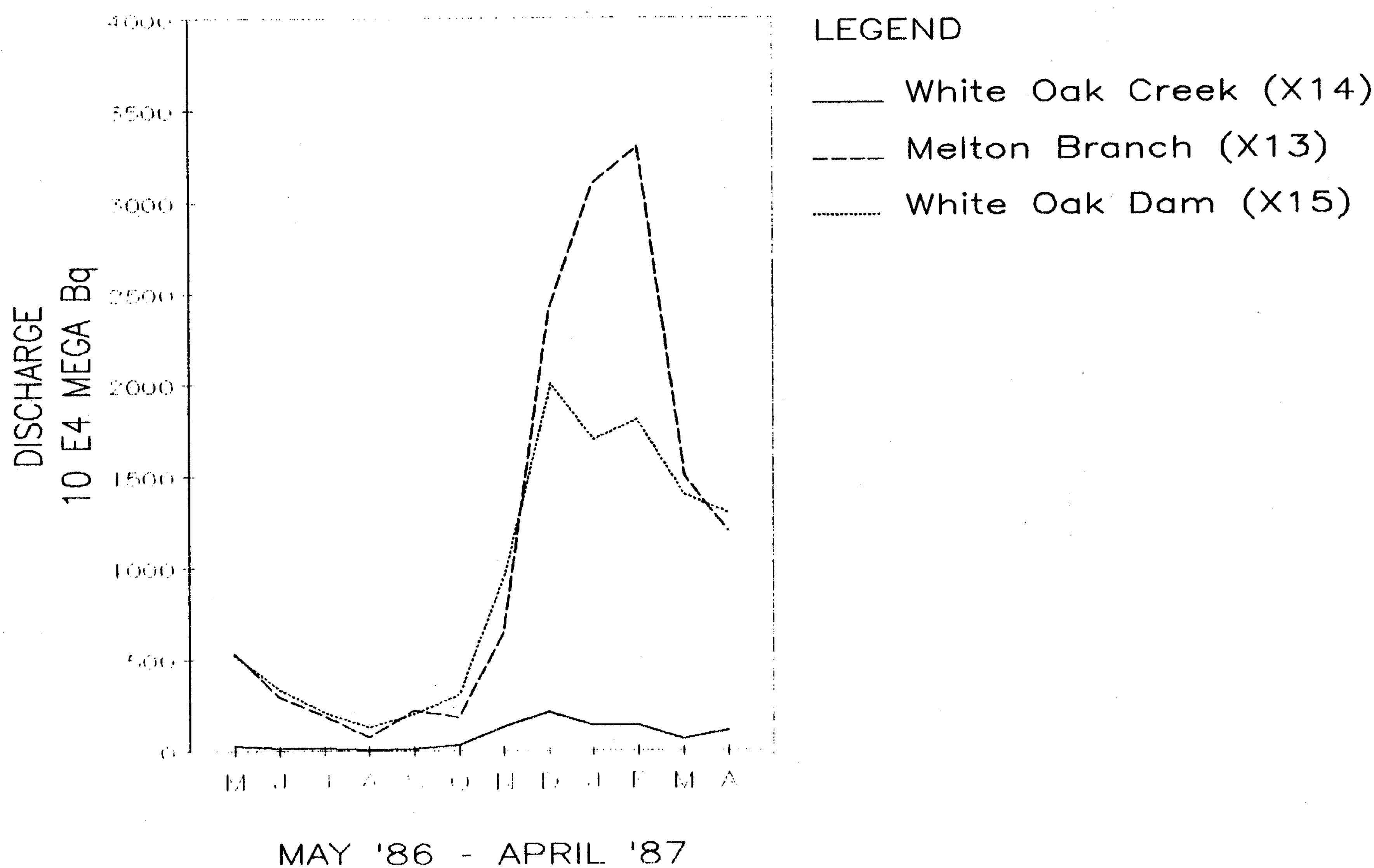


FIG. 9. Monthly discharge of tritium in surface waters



Outfalls to the White Oak Creek Flow System

Water is supplied to the ORNL plant site from the DOE water treatment plant at an average rate of approximately 4.0 million gallons per day (MGD) [6.19 CFS]. This water is then distributed to ORNL facilities through two separate systems: potable and process. Of the total amount of imported water, 38% [1.53 MGD (2.37 CFS)] is lost to the atmosphere as evaporation. The remaining 62% [2.47 MGD (3.82 CFS)] is subsequently discharged to the White Oak Creek surface water system (Kasten 1986). These discharges are categorized under the ORNL NPDES permit that was issued April 1, 1986. Fig. 10 summarizes the water balance of the ORNL plant site with emphasis on treated water supply.

Under the requirements of the Clean Water Act, NPDES Permit No. TN0002941 was issued to ORNL to monitor point sources at their point of discharge into receiving streams. Point Source Outfalls are discernable, confined, and discrete conveyances from which a process stream is discharged to receiving waters. The effluent must be monitored before it reaches the receiving water, or mixes with any other wastewater stream. The permit identifies at least 176 stations; however, 10 major effluent discharges (Point Source Outfalls) regulated under the permit (Fig. 11) account for approximately 83% of the water discharged to the WOC system. Table 9 identifies these outfalls and their average discharges into receiving streams. One additional Point Source Outfall described under the NPDES permit is the planned Non Radiological Wastewater Treatment Facility (NRWTF), NPDES outfall No. X12. The expected average daily discharge from the facility is five hundred thousand gallons per day (0.77 CFS). Compliance level is expected to be attained by March 1990.

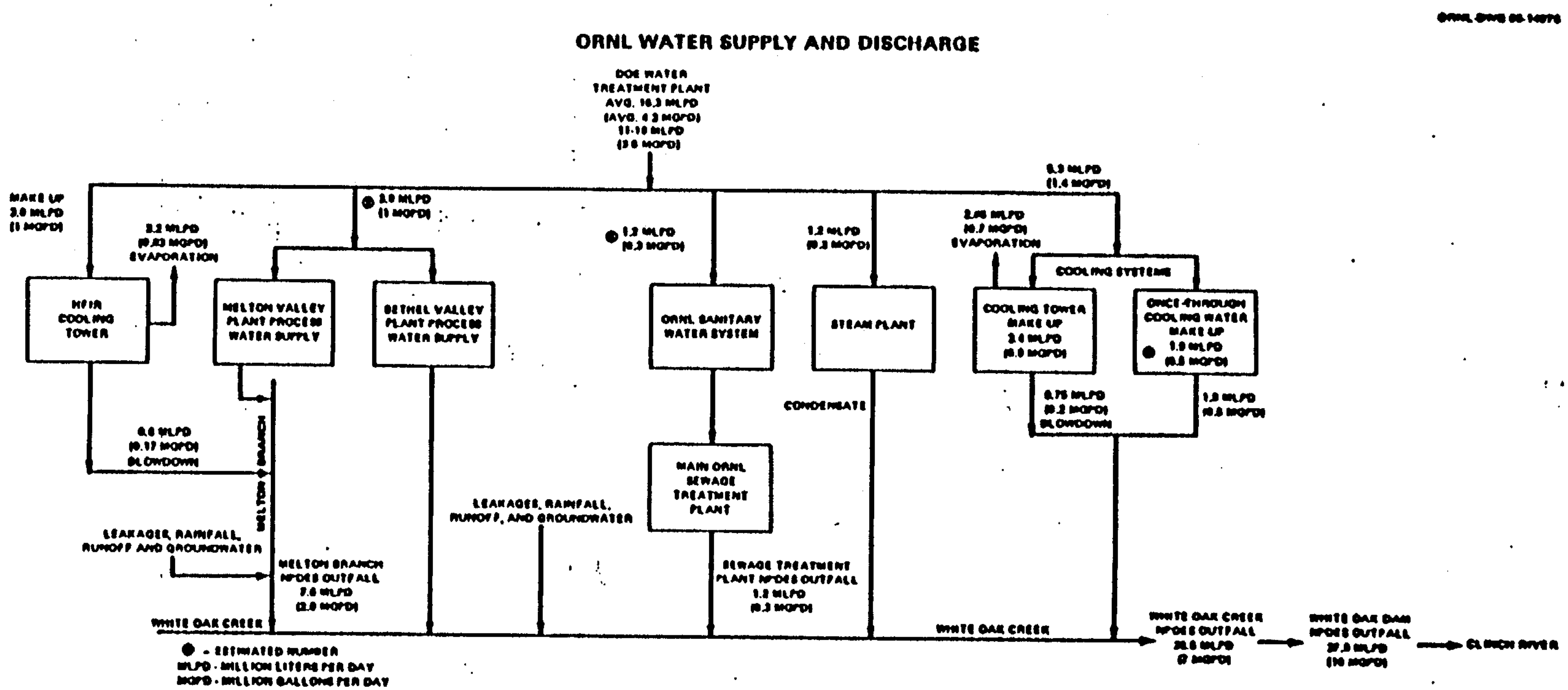


Fig. 10. ORNL water supply and discharge.

SOURCE: Kasten 1986

NPDES Monitors

1. 1500 Area (X3)
2. Sewage Treatment Plant (X1)
3. Coal Yard Runoff Treatment Facility (X2)
4. Process Waste Treatment Plant (X07)
5. Acid Neutralization Facility (X11)
6. 190 Ponds (X6)
7. Nonradiological Wastewater Treatment Facility
8. 2000 Area (X4)
9. ORR Resin Regeneration Facility (X10)
10. White Oak Dam (X15)
11. White Oak Creek (X13)
12. Melton Branch (X14)
13. TRU Ponds (X8)
14. HFIR Ponds (X9)

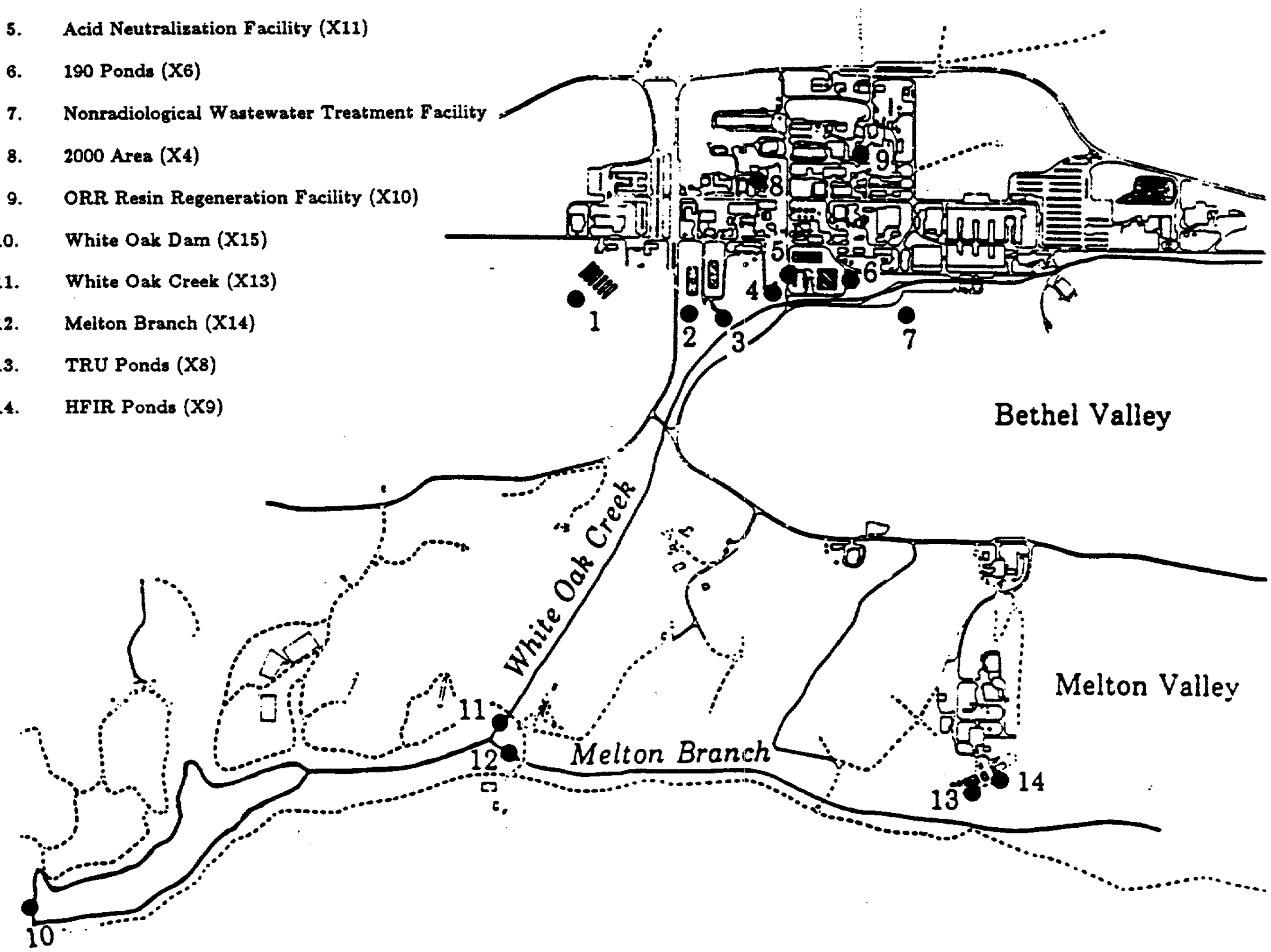


Fig. 11 Location of NPDES effluent (Sites 1-9 and 13-14) and instream (Sites 10-12) water quality monitoring stations (after Loar et al. 1987). Source: ORNL Department of Environmental Management (1986a, Fig. 8).

Table 9. Description of the 10 major effluent discharges regulated under the ORNL NPDES permit that was issued April 1, 1986. Discharge locations are shown in Fig. 11. (Loar et al. 1987) Source: EPA (1986).

Receiving stream	Source of effluent discharge	NPDES outfall no.[a]	Average flow rate (L/s)[b]
Fifth Creek	ORR[c] resin regeneration facility	X10	0.4(0.01)[d]
Melton Branch	TRU[c] process waste basins	X08	2.2(0.08)[d]
	HFIR[c] process waste basins	X09	7.0(0.25)[d]
Northwest Tributary	1500 area	X03	0.3(0.01)
White Oak Creek	Sewage Treatment Plant	X01	10.1(0.36)[e]
	Coal Yard Runoff Treatment Facility	X02	1.0(0.04)[e]
	2000 area	X04	0.6(0.02)
	3539 and 3540 ponds	X06	5.9(0.21)[d]
	3544 Process Waste Treatment Plant	X07	7.9(0.28)[e]
	3518 Acid Neutralization Facility	X11	1.8(0.06)[d]

[a]No outfall X05 exists; outfall X12 is the planned discharge from the Nonradiological Wastewater Treatment Facility scheduled for completion in 1989 with a March 1990 date for compliance and an estimated average flow rate of 22 L/s (0.8 cfs).

[b]Discharge in cubic feet per second (cfs) in parentheses; for batch operations, average flow rate is based on days when waste is discharged.

[c]ORR = Oak Ridge Reactor; TRU = Transuranium Processing Facility; HFIR = High Flux Isotope Reactor.

[d]Batch discharge with frequencies of once every 5 d (X08), three times per month (X09), once every 5–8 d (X10), and 3 batches per d (X11); discharge X06 is batch if radioactivity is below predetermined levels.

[e]Maximum flow rates are 32.9 L/s (1.16 cfs) at X01, 9.6 L/s (0.34 cfs) at X02, and 18.8 L/s (0.67 cfs) at X07.

Additional outfalls to WOC are divided into categories according to effluent limitations and monitoring requirements. The following is a description of each category as well as the type of outfalls:

Category I Outfalls - Storm Drains

These storm drains are uncontaminated by any industrial or commercial activity and do not discharge through any oil/water separator or other treatment equipment or facility. Once per year each of the Category I Outfalls shall be sampled to verify minimal releases of pollutants to the environment. Limits have been placed on the following parameters: pH, temperature, oil and grease, and total suspended solids.

Category I Outfalls

Location	Total
White Oak Creek	16
First Creek	4
Fifth Creek	13
Melton Branch	1
	34

Category II Outfalls - Roof Drains, Parking Lot Drains, Storage Area Drains, Spill Area Drains, Once-Through Cooling Water, Cooling Tower Blowdown, and Condensate.

A Best Management Plan (BMP) is to be imposed on the discharges from Category II type outfalls contaminated by an industrial or commercial activity and not discharged through any oil/water separator or other treatment equipment or facility. Category II Outfalls shall be sampled quarterly to verify minimal releases of pollutants to the environment. Limits have been placed on the following parameters: pH, temperature, oil and grease, and total suspended solids.

Category II Outfalls

Location/Type	Subtotal	Total
White Oak Creek:		
Parking Lot Runoff	27	
Condensate	4	
Cooling Tower Blowdown	2	
Spill Area Drain	1	34
First Creek:		
Parking Lot Runoff	8	
Storage Area Drain	2	10
Melton Branch:		
Parking Lot Runoff	3	
Cooling Tower Blowdown	1	4
Fifth Creek:		
Parking Lot Runoff	6	
Condensate	4	
Cooling Tower Blowdown	3	13
		61

Category III Outfalls - Process and/or Lab Drains

There shall be no discharge of process wastewaters to the waters of White Oak Creek, Fifth Creek, Melton Branch, and Melton Hill Lake which may have an adverse impact on human health or to the environment. This condition applies to Category III outfalls. Category III Outfalls shall be sampled quarterly to verify minimal releases of pollutants to the environment. These outfalls are actually either Category I or

Category II Outfalls, but because of inflow/infiltration, cross-connects, or improper disposal of chemicals, have become contaminated with pollutants. The only limitation placed on these outfalls is pH.

Category III Outfalls

Location/Type	Total
White Oak Creek:	
Process Drains	14
First Creek:	
Process Drains	4
Melton Branch:	
Settling Ponds	6
Fifth Creek:	
Process Drains	8
	32

Miscellaneous Source Discharges

These discharges have not been identified in the NPDES permit as a serial numbered discharge. Each is specific to a special category identified by the EPA. Limitations have been placed on all Miscellaneous Source Outfalls. The following facilities have been placed in those categories:

26 Cooling Towers

1 Boiler (Bldg. 2519, Central Steam Plant)

1 Vehicle and Equipment Cleaning Facility (Bldg. 7002)

1 Painting and Corrosion Control Facility (Bldg. 7007)

1 Vehicle and Equipment Maintenance Facility (Bldg. 7002)

4 Photographic Laboratories (Bldgs. 1500, 4500N, 7934, 7601)

1 Firefighter Training Area (outside Bldg. 2500)

Contaminants in Sediments

Studies of WOC streambed gravels as indicators of the degree and location of sources radiological contamination (Cerling 1985 and Cerling and Spalding 1981) were continued during 1986-1987. A RAP report released in May (Cerling et al. 1987) documented the results of studies of new sources of ^{90}Sr and ^{137}Cs in First Creek and upper WOC (behind ORNL Main Plant).

Reports have also been completed on current studies to (1) quantify radionuclide flux at selected sites based on radionuclide and metal concentrations on gravels and the associated streamflow, and (2) determine the mechanisms and rates of radionuclide and metal sorption and desorption on streambed gravels.

An aerial radiological survey was conducted during October 1986 to provide detailed information on the nature and location of radiological contaminants in floodplain sediments. The study report by EG&G Energy Measurements (1987) describes the survey methodology and shows detailed contours on total radiological exposure (Fig. 12), ^{137}Cs, ^{60}Co, and ^{208}Thallium on aerial photographs of the floodplain.

Groundwater

Radioactive nuclides have been detected in groundwater at most of the waste area units at ORNL. Also, a significant part of the contamination which enters the WOC flow system is derived from groundwater. Thus, the characterization of groundwater movement and quality has been the subject of many environmental studies in the past and it is a major element of the remedial action program. Large numbers of wells have been drilled during pre-RAP studies and in the remedial action program.

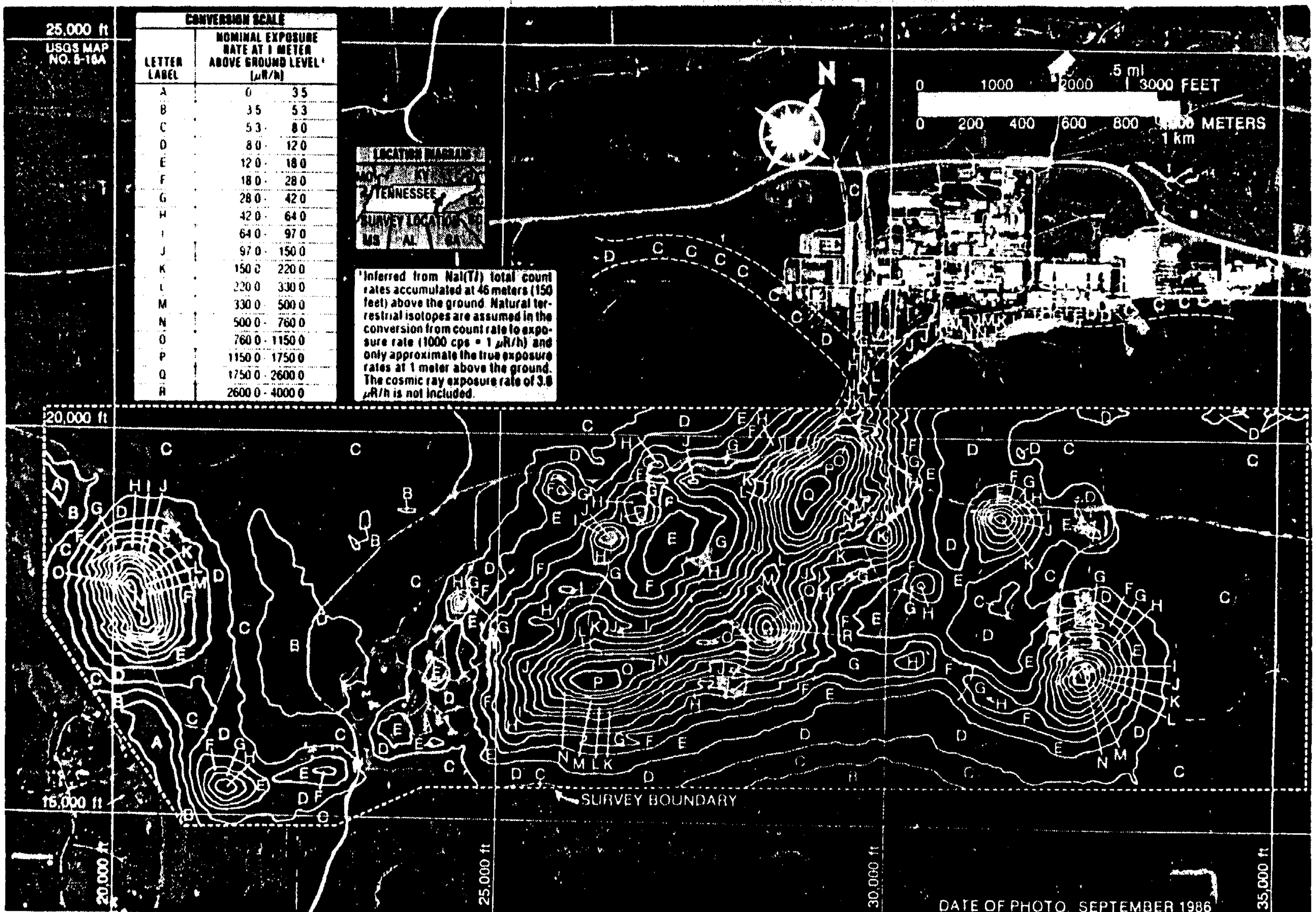
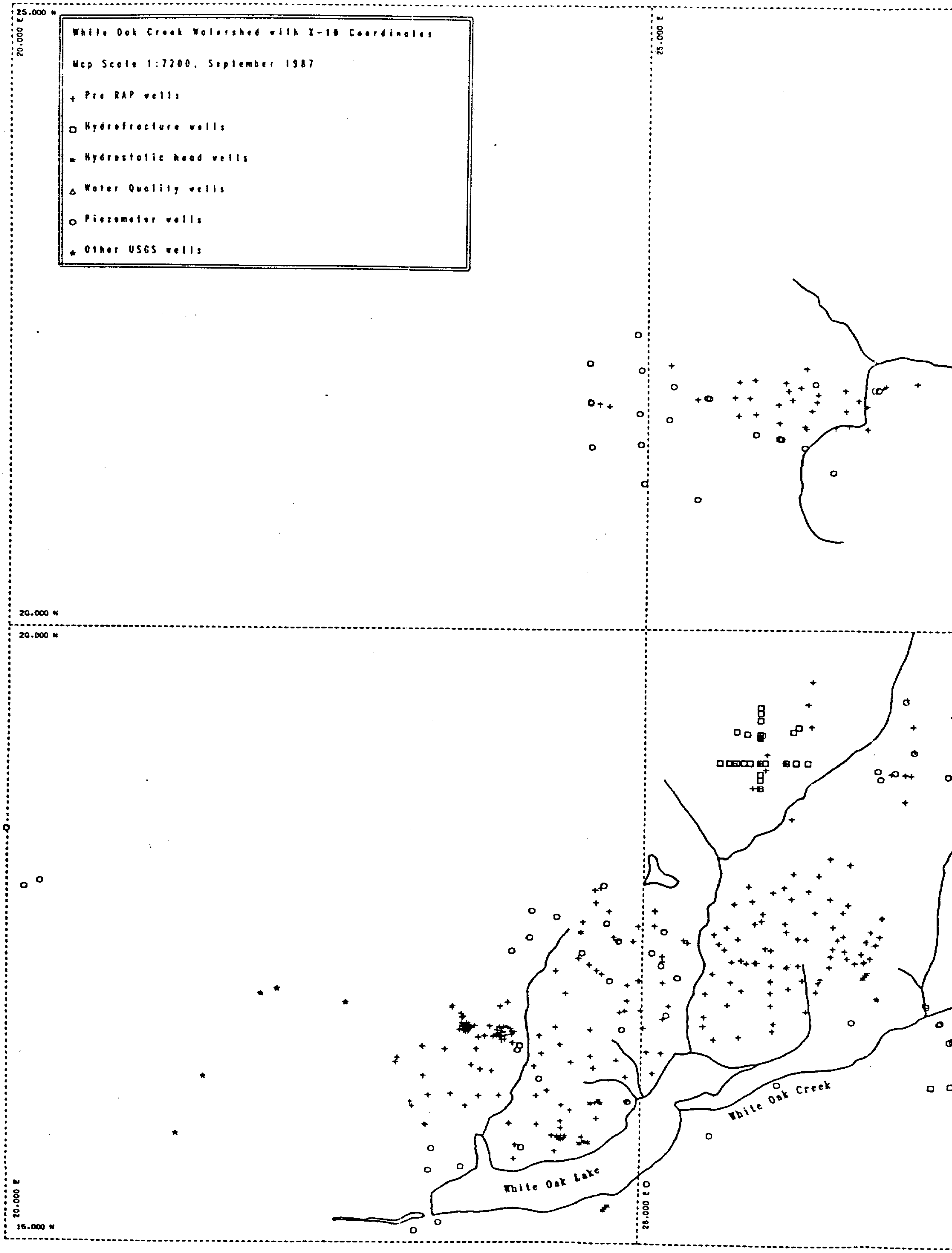


Fig. 12. Terrestrial exposure rates in the White Oak Creek Floodplain, ORNL.

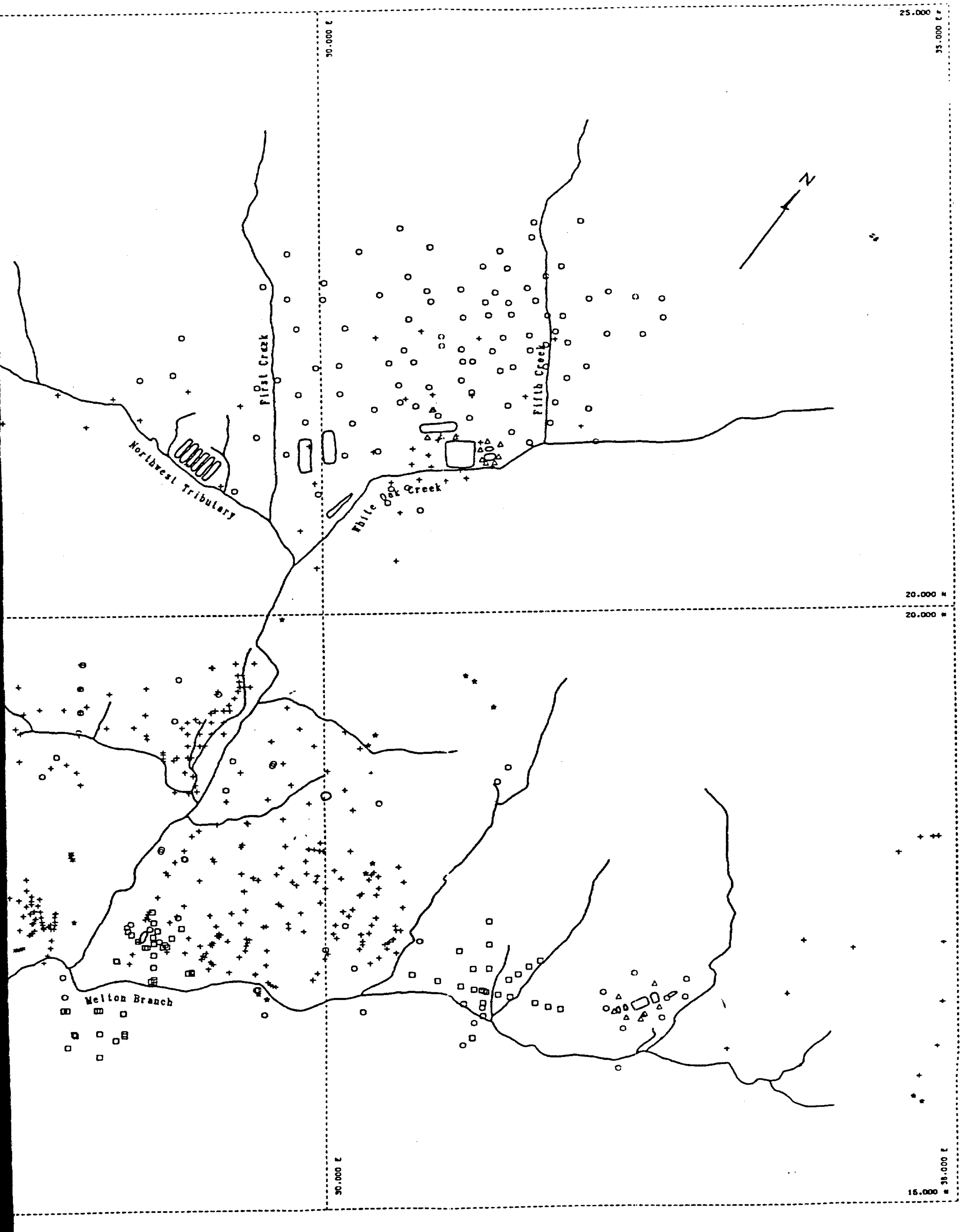
Because of the complex nature of the subsurface materials, the contaminants entering the groundwater flow system, and the studies required, over 1100 wells have been drilled in the watershed since the inception of the ORNL. Information on most of these wells is included in the RAP data base management system (Fig. 13). Approximately 310 shallow piezometers, 50 water quality monitor wells, 20 hydrostatic head wells in multiple well clusters, 15 hydrofracture monitor wells, and 10 core holes have been completed to date as part of the RAP program in the WOC watershed. The locations of wells or piezometers for which construction data and elevations have been entered into the RAP data base management system are shown in Fig. 14 with symbols showing the primary type of data being collected. A number of RAP reports describing different phases of the drilling program are listed in Appendix B.

A water level data base has been established which includes measurements collected on a regular basis in the shallow piezometers. Hydrographs for selected piezometers (shown in Fig. 14), plotted from this data base, are shown in Fig. 15. Continuous water level recorders are maintained by the U.S. Geological Survey on over 90 wells of various depths in the watershed (Fig. 16). Selected hydrographs of water levels in these wells and precipitation are shown in Fig. 17. A water table contour map prepared from measurements made in piezometers in the White Oak Creek floodplain during May 1987, is shown in Fig. 18 (McCrackin 1987).

Hydraulic conductivity (slug) tests have been conducted in more than 190 shallow piezometers in the watershed, and results have been entered into the digital data base. The results of tests in the WOC fig 13 p.42



25.000 N
20.000 E
25.000 E
White Oak Creek Watershed with X-10 Coordinates
Map Scale 1:7200, September 1987
+ Pre RAP wells
□ Hydrofracture wells
* Hydrostatic head wells
△ Water Quality wells
○ Piezometer wells
* Other USGS wells
20.000 N
20.000 N
White Oak Creek
White Oak Lake
20.000 E
16.000 N
25.000 E



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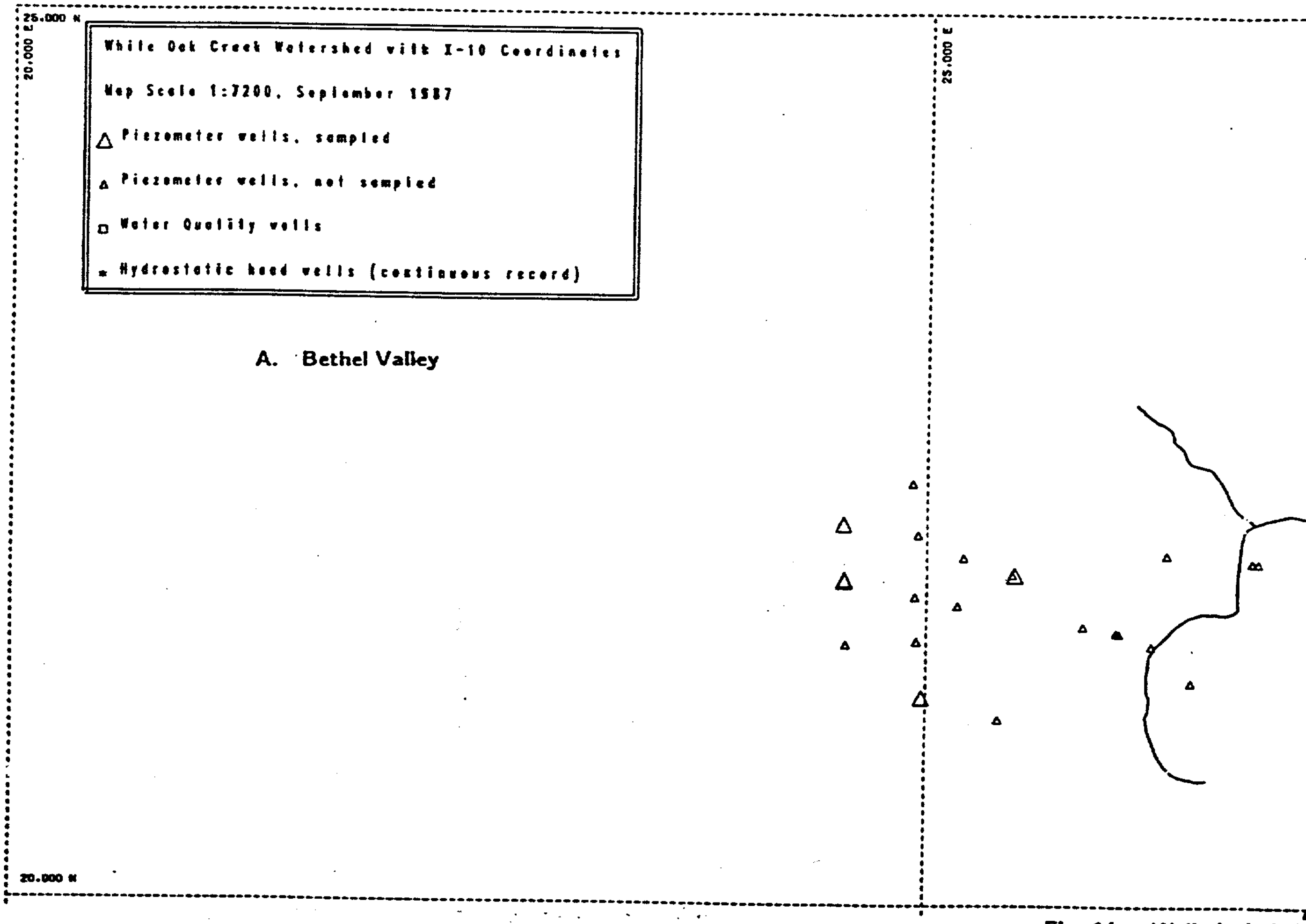
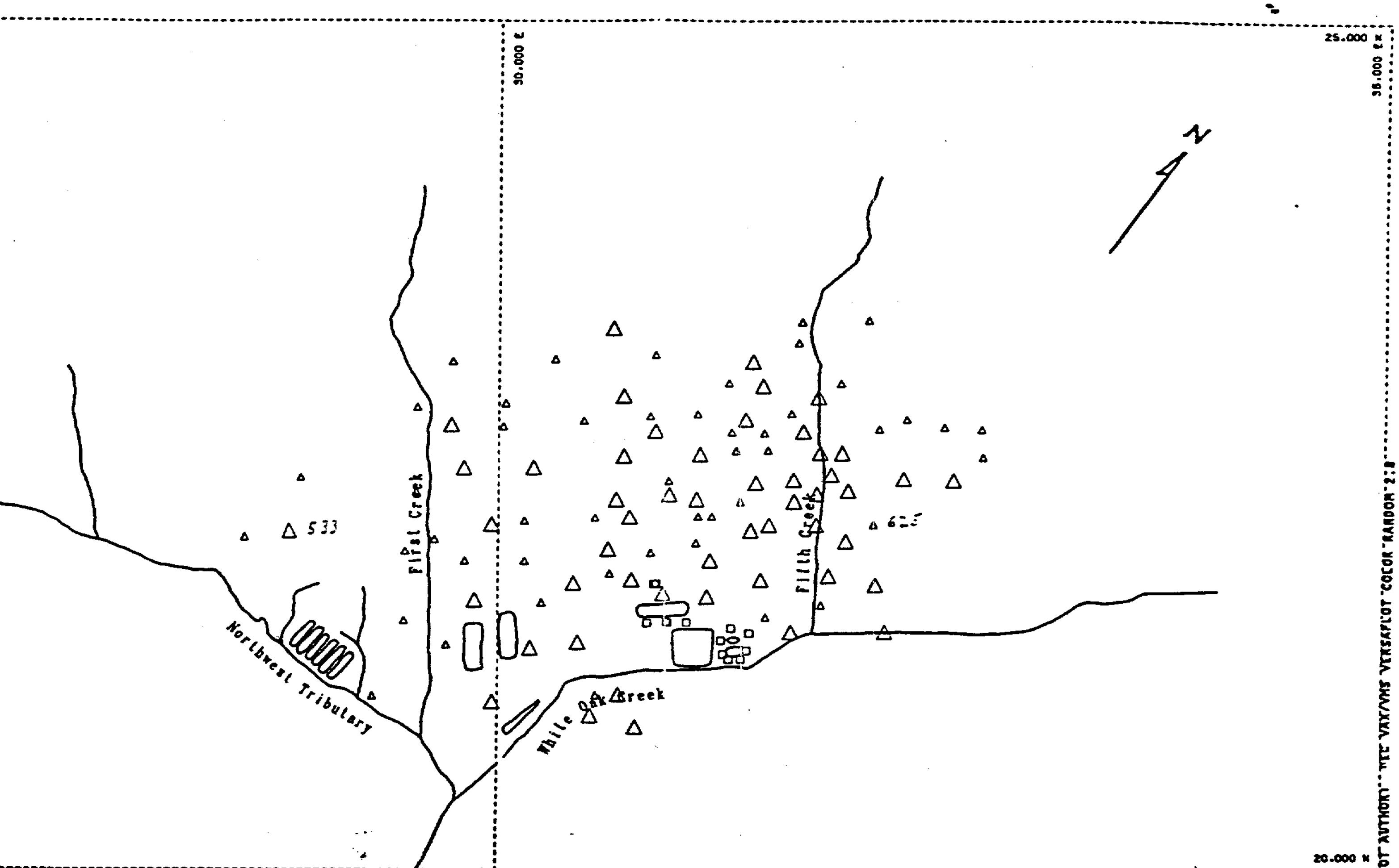


Fig. 14. Wells included



the RAP data base which were installed during the remedial action program (1985 to the present).

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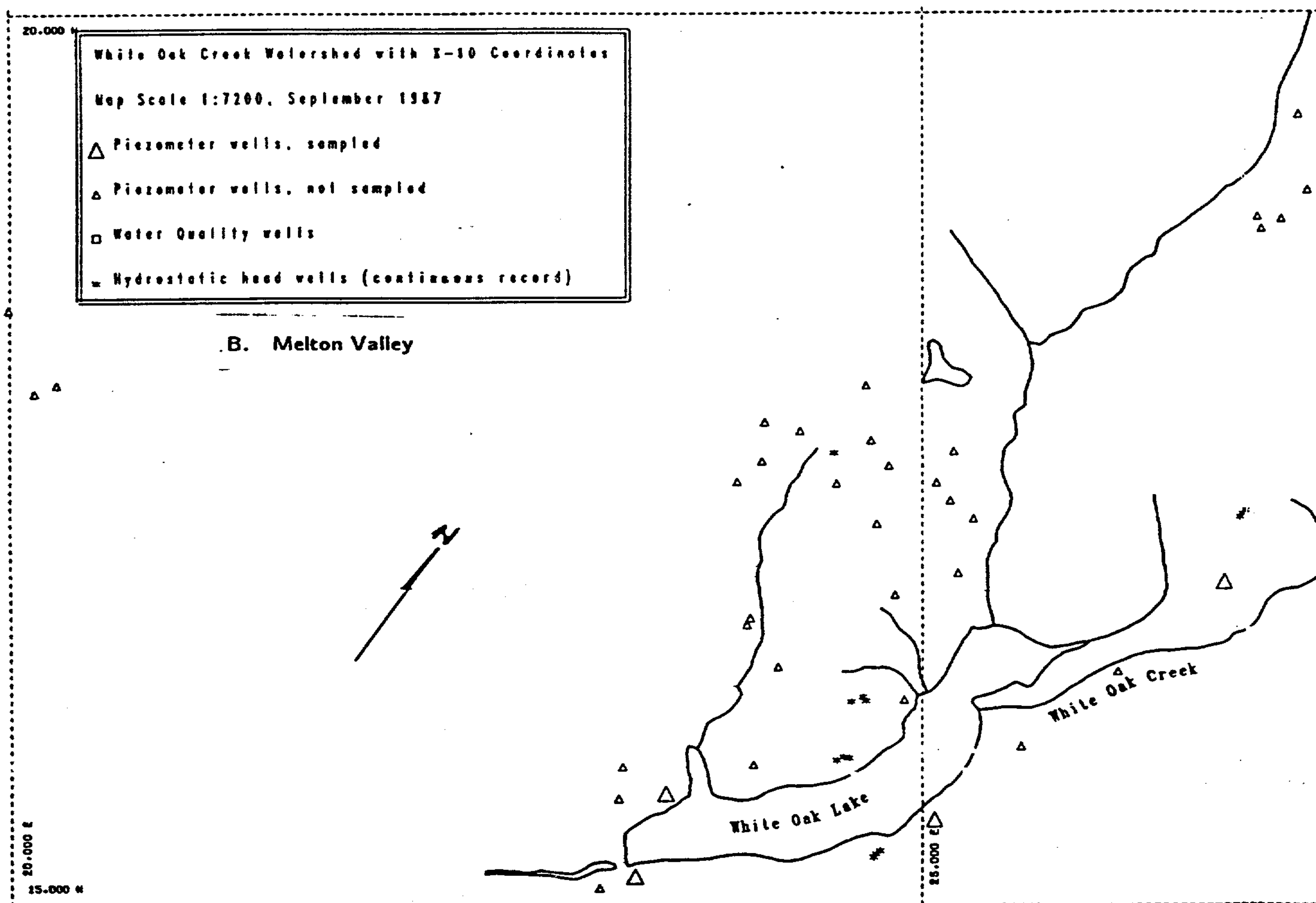
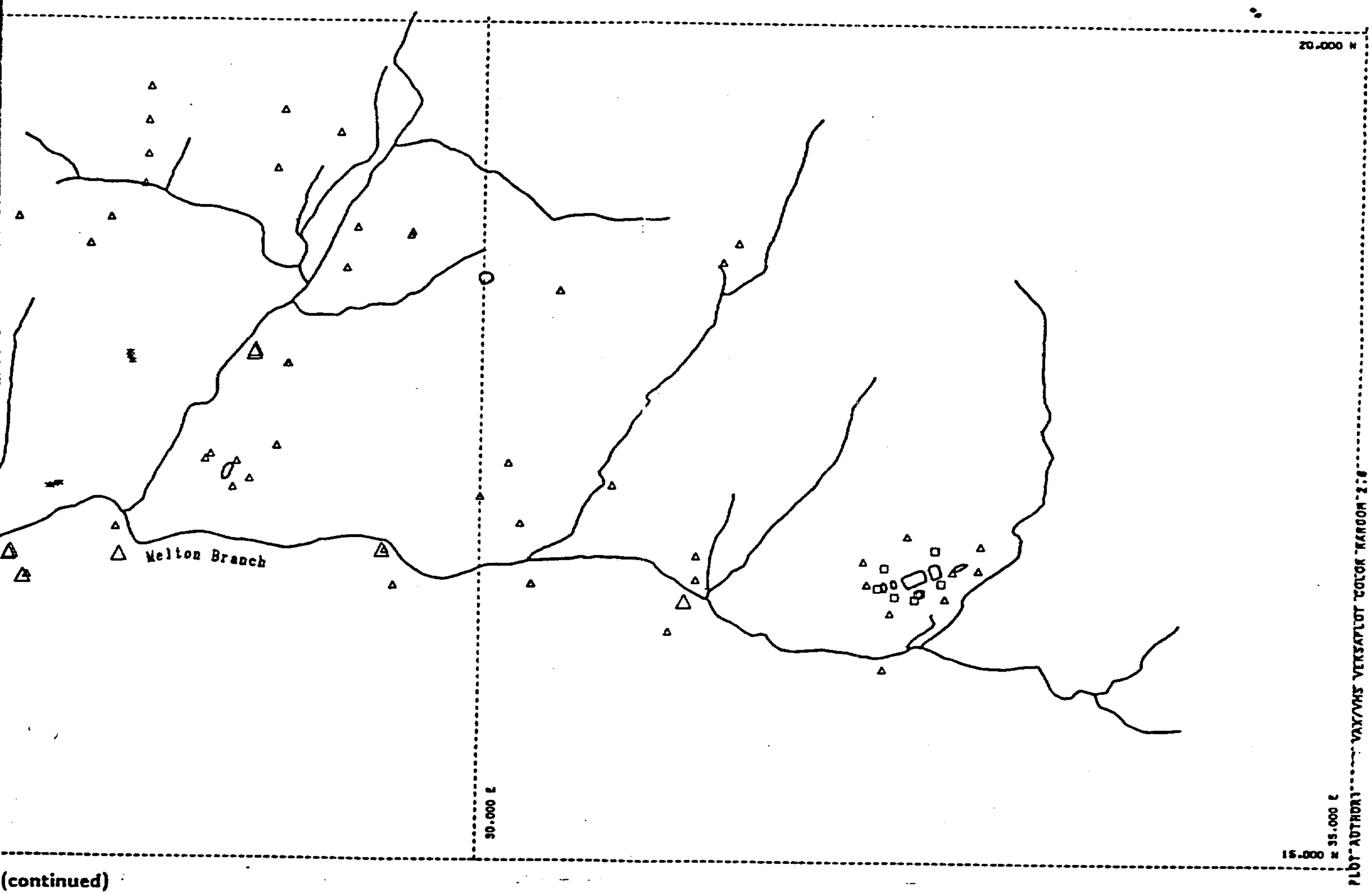
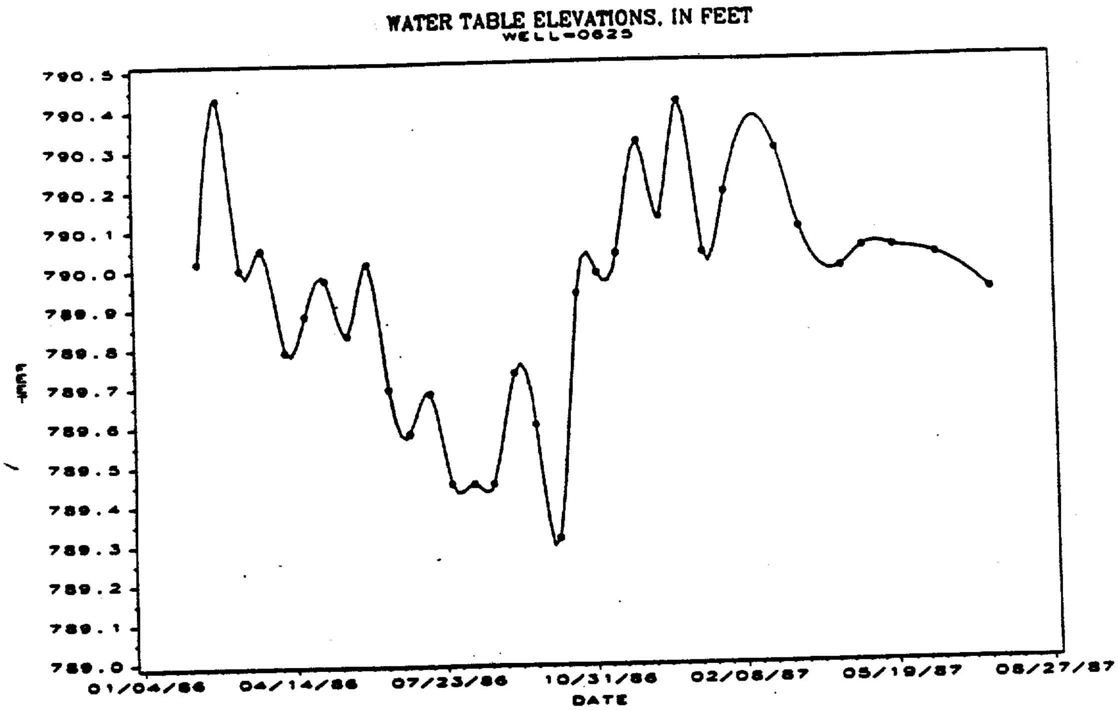


B. Melton Valley

Fig. 14



(continued)



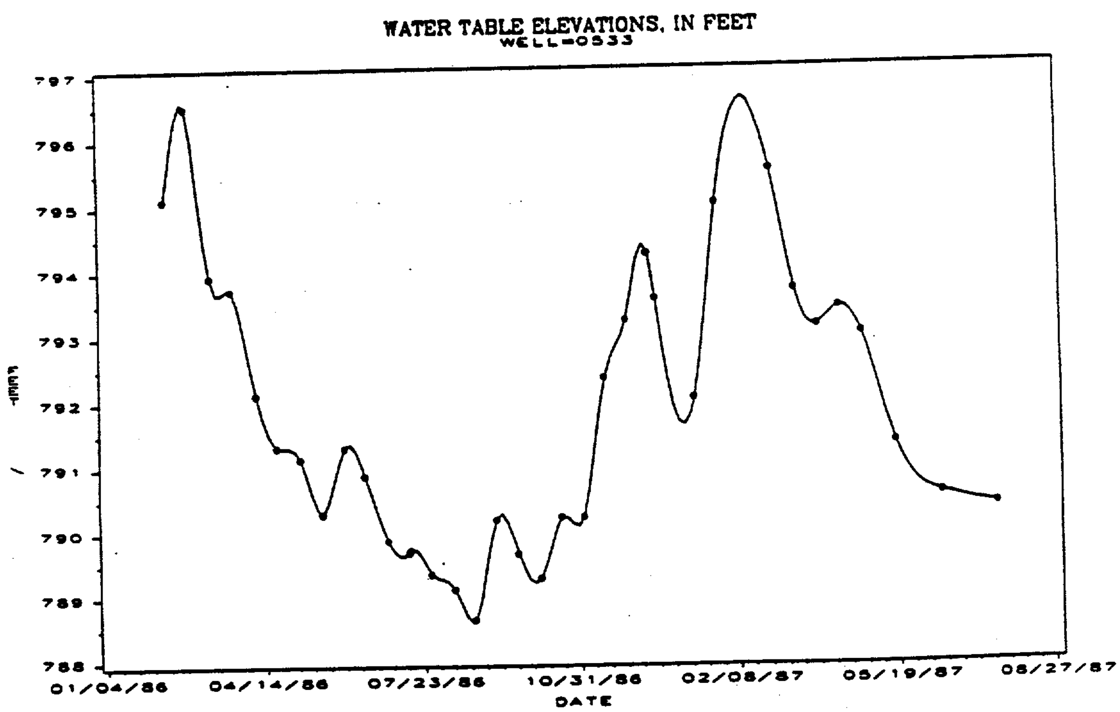


Fig. 15. Hydrographs plotted from measurements in selected piezometers in the White Oak Creek watershed.

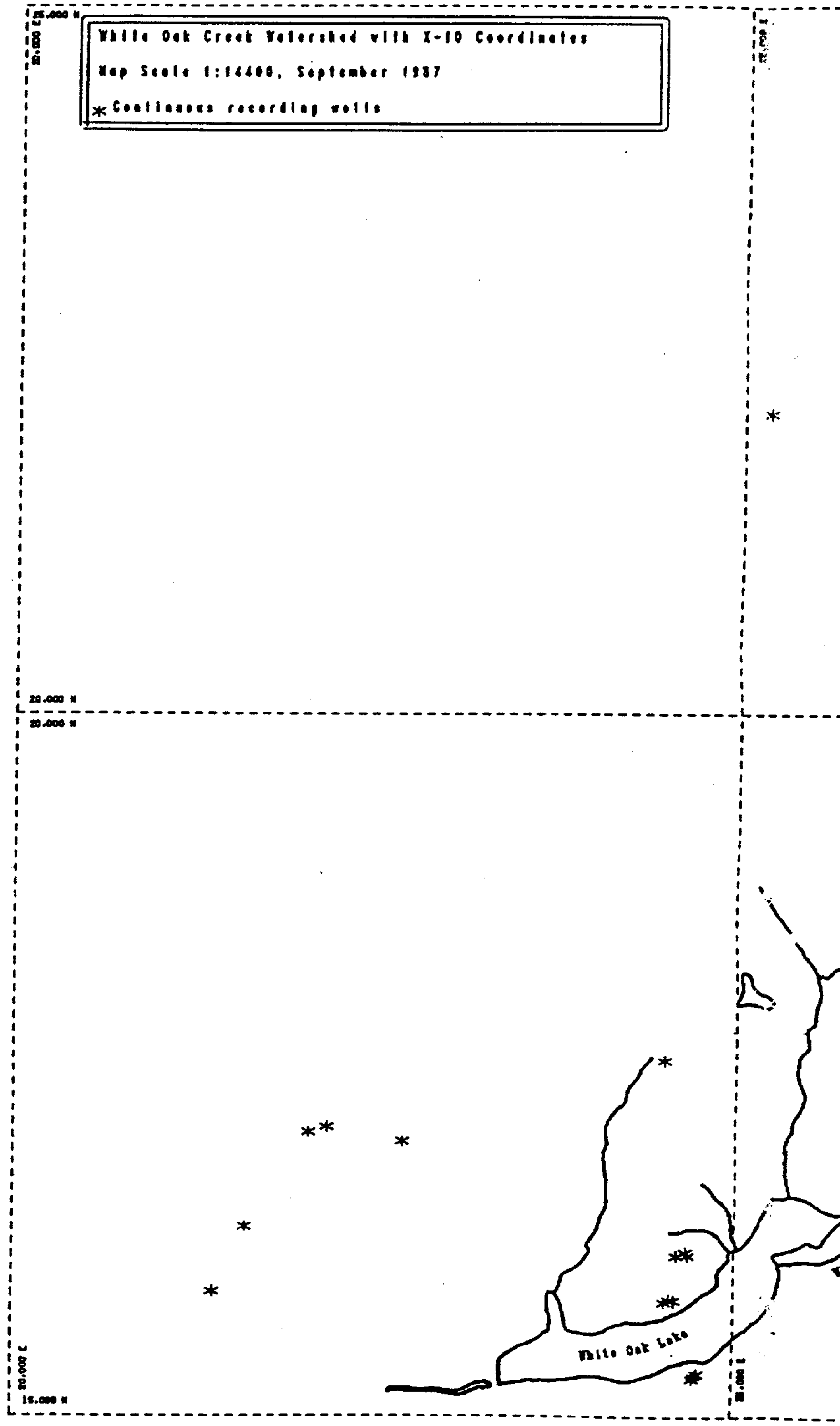
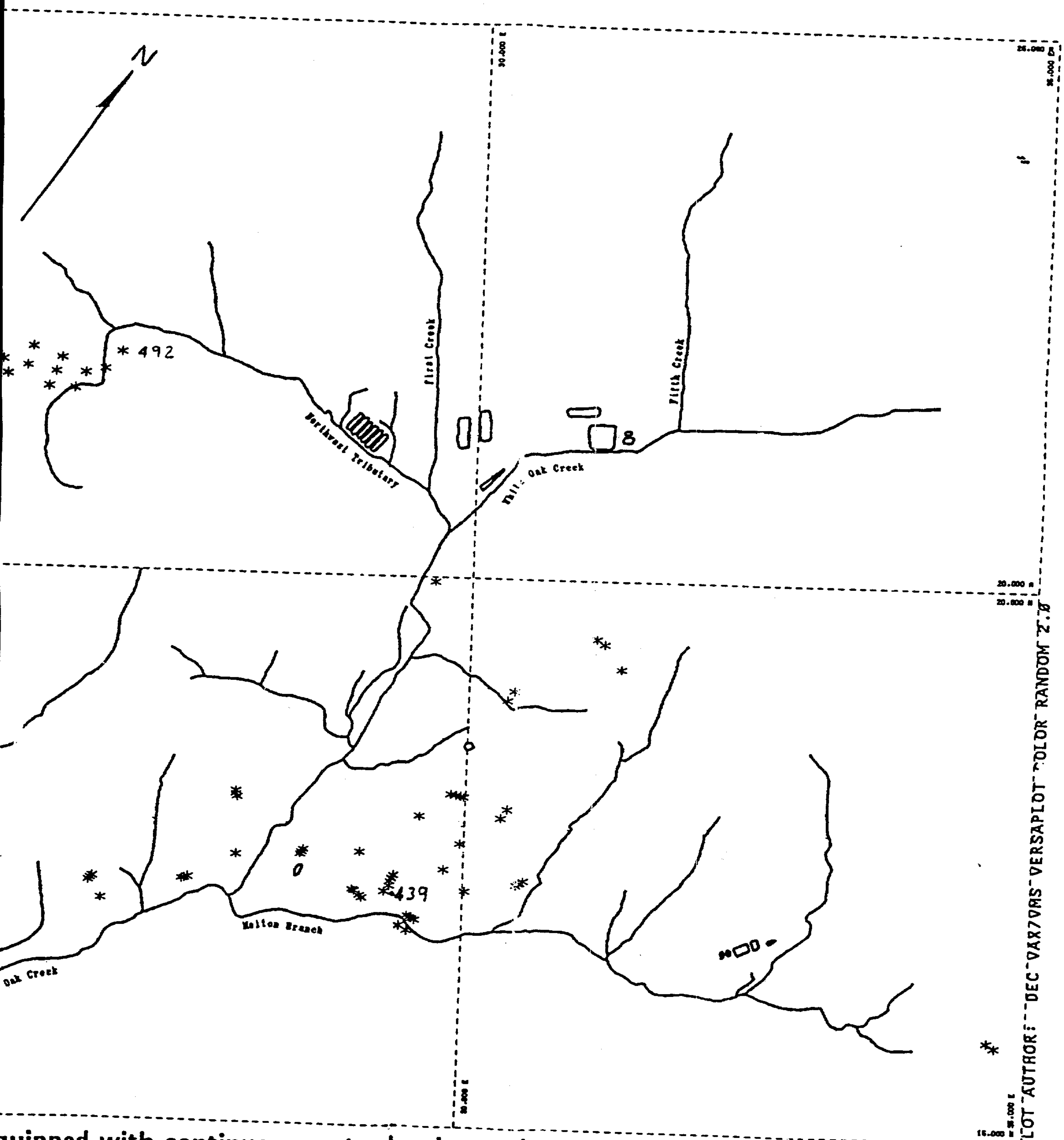
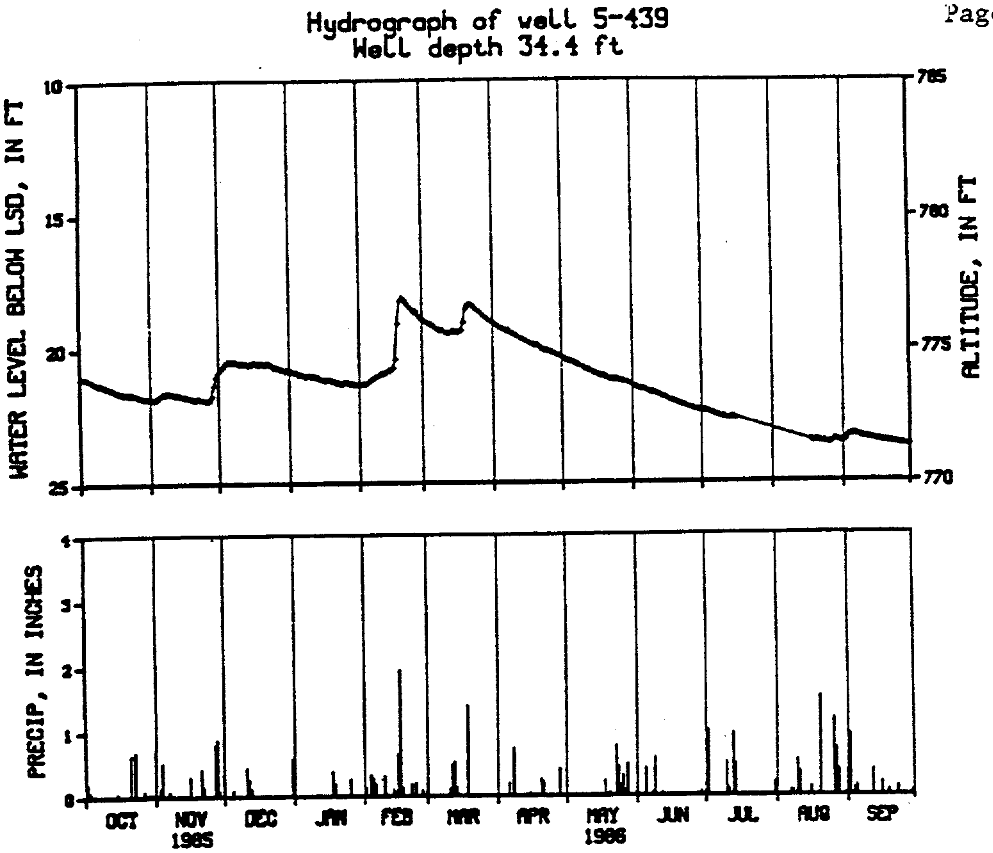

White Oak Creek Watershed with X-10 Coordinates
Map Scale 1:14400, September 1987
* Continuous recording wells
25,000 N
20,000 N
20,000 N
15,000 N
White Oak Lake

Fig. 16. Wells



quipped with continuous water level recorders.



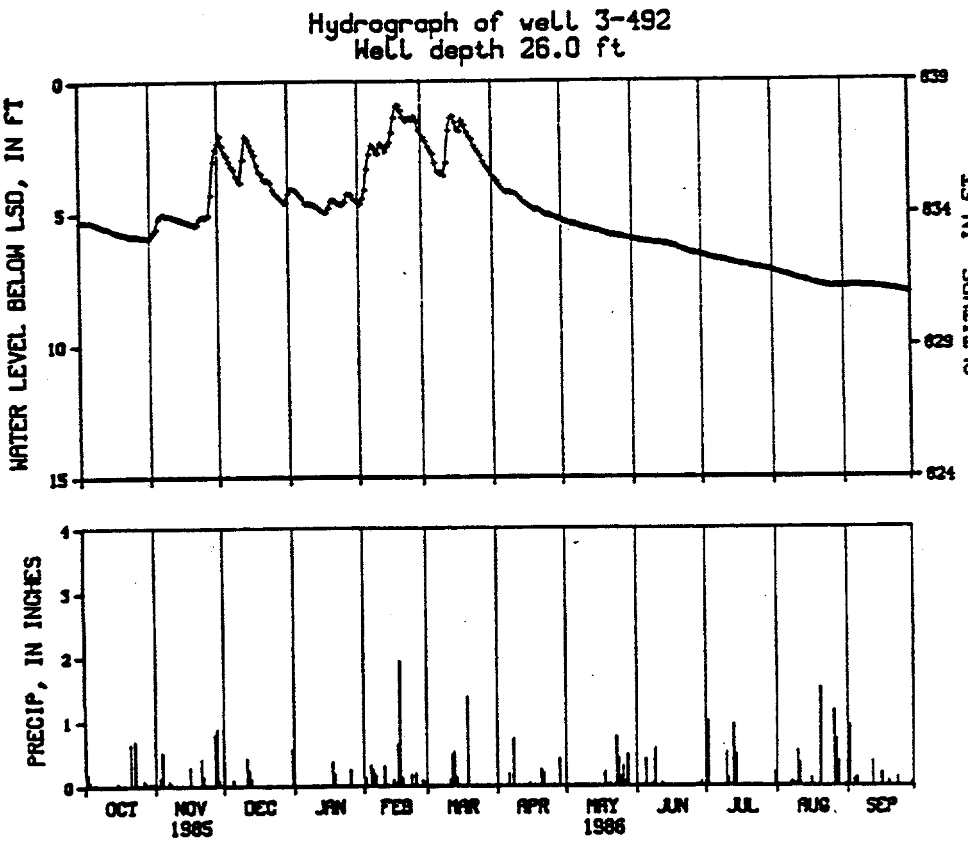
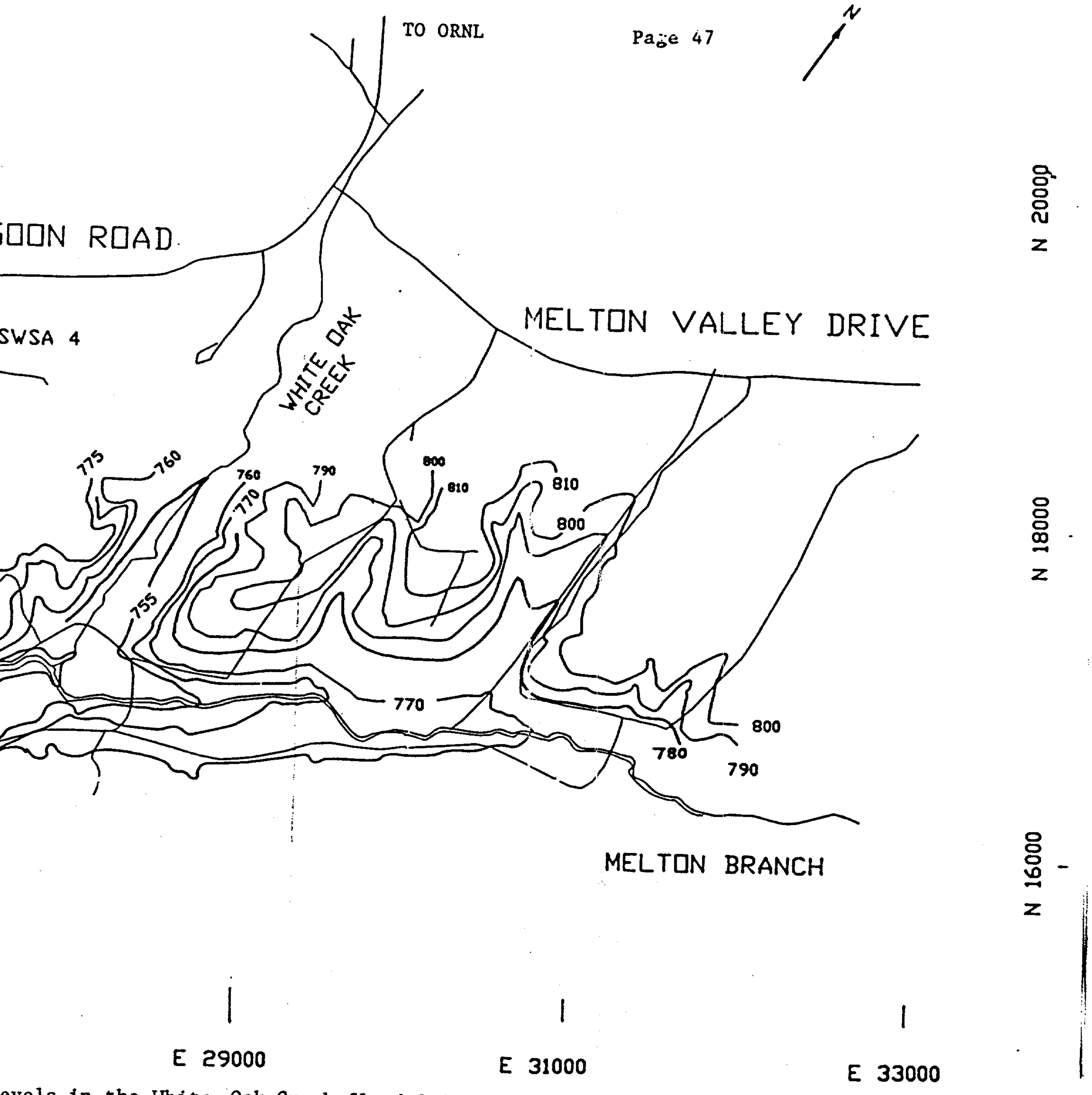


Fig. 17. Hydrographs of water levels and precipitation for selected wells equiped with continuous recorders in the White Oak Creek watershed.

P. 47

Fig. 18. Contours on wa



evels in the White Oak Creek floodplain, May 1987 floodplain (Fig. 19) are shown in Table 10 (McCrackin et al. 1987). Rock core and geophysical logs from a 900-ft core hole drilled at White Oak Dam indicate fractured rock throughout the length of the core hole but suggest little groundwater flow below a depth of 400 feet. The analyses of samples of water collected at depths of 44 feet and 270 feet showed no radiological contamiation (Selfridge and Sherwood 1987). Subsequent packer-pressure tests were conducted in the core hole to provide estimated permeability values for different water-bearing zones. RAP reports on packer pressure testing of the WOD core hole and 5 core holes in the main plant area are in preparation (Golder and associates, in press).

Analytical results for chemical and radiological analyses of samples from more than 100 wells are included in the RAP data base. The results of analysis of scoping samples from 27 shallow piezometer wells in the WOC floodplain (Fig. 20) in Table 11 show instances of chemical and radiological contamination of the shallow groundwater (McCrackin et al. 1987). A RAP report containing a summary of results of contaminant analyses from selected piezometers in the main plant area is in preparation to be issued during September (Ketelle, personal communication).

Reports

A large number of reports which contain hydrologic data or information have been released by ORNL. A listing of abstracts of RAP reports which are included in the information data base are included in Appendix B. Information on reports in other ORNL series may also be retrieved from the RAP bibliographic data base (see ORNL/RAP/LTR-87/4 in Appendix B).

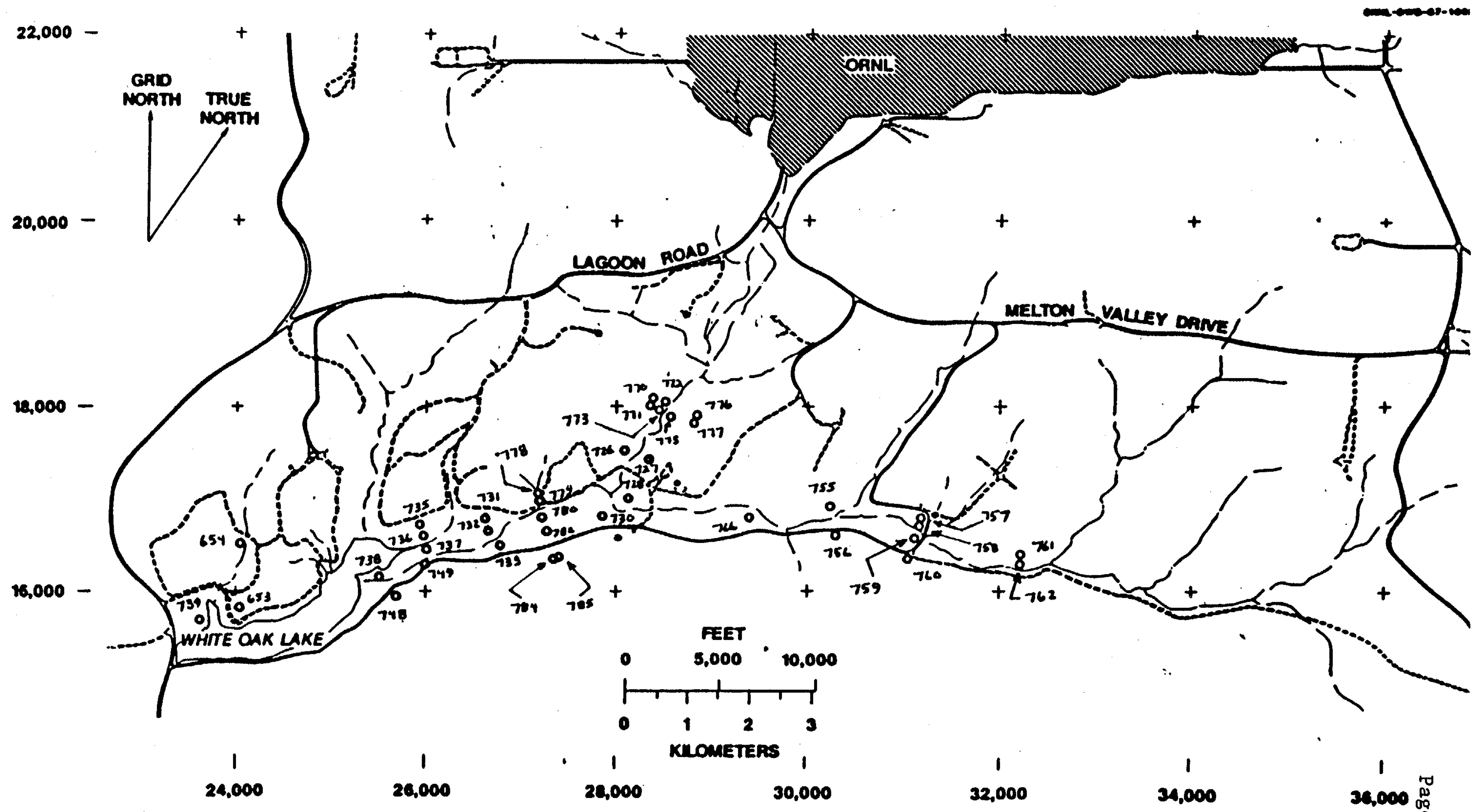


Fig. 19. Piezometers tested for hydraulic conductivity in the White Oak Creek Floodplain.

Table 10a. Hydraulic conductivity values calculated from slug tests on piezometers in the White Oak Creek Floodplain (McCrackin et al. 1987).

Well No.	Bouwer & Rice Method K (m/day)	Model Method K (m/day)	HVORSLEV Method K (m/day)
653	0.248	0.261	0.301
654	0.226	0.184	0.278
657	0.081	0.103	0.129
664	0.016	0.025	0.027
667	0.037	0.048	------
726	0.010	0.013	------
727	0.067	0.082	------
728	0.323	0.371	0.549
730	0.058	0.095	0.328
731	0.064	0.107	0.110
732	0.159	0.155	0.078
733	0.066	0.079	------
735	0.174	0.269	0.206
737	0.623	0.811	0.733
738	0.044	0.046	------
739	0.038	0.056	0.060
748	0.082	0.135	0.140
749	0.086	0.146	0.158
755	0.071	0.088	------
756	0.178	0.281	0.296
757	0.151	0.179	0.227
758	0.029	0.036	0.055
759	0.256	0.260	0.429
760	0.126	0.150	0.198
761	0.044	0.055	------
766	0.230	0.372	0.377
770	0.012	0.017	------
771	0.029	0.045	0.131
772	0.226	0.217	0.386
773	0.012	0.011	------
775	0.014	0.017	------
776	0.053	0.067	0.086
777	0.006	0.010	------
778	0.207	0.254	0.330
780	0.198	0.303	0.338
782	0.300	0.331	0.528
784	0.036	0.048	------
785	0.012	0.009	------

Table 10b. Transmissivity values calculated from slug tests on piezometers in the White Oak Creek Floodplain (McCrackin et al. 1987).

Well No.	Bouwer & Rice Method	Model Method (m^2/day)	HVORSLEV Method
653	------	0.442	------
654	------	0.312	------
657	0.489	0.193	------
664	0.084	0.043	0.080
667	0.292	0.056	0.230
726	0.033	0.021	0.027
727	0.107	0.089	0.037
728	0.932	1.072	------
730	0.179	0.274	0.920
731	0.139	0.132	0.285
732	0.190	0.176	0.199
733	0.096	0.129	0.187
735	0.531	0.263	0.352
737	1.614	0.809	0.748
738	0.087	0.087	0.089
739	0.224	0.127	0.282
748	0.082	0.221	0.623
749	0.247	0.506	0.498
755	0.075	0.460	0.054
756	0.802	2.380	------
757	0.917	0.195	------
758	0.151	0.041	0.046
759	1.377	0.850	1.700
760	0.727	0.900	0.350
761	------	0.594	------
766	0.787	0.978	0.678
770	0.160	0.078	0.050
771	0.106	0.109	0.111
772	0.885	0.800	0.600
773	0.177	0.060	0.050
775	------	0.038	0.058
776	0.229	------	0.250
777	0.075	0.040	0.037
778	0.830	0.250	0.767
780	0.688	0.508	0.797
782	1.179	0.712	0.997
784	0.135	0.030	0.110
785	0.150	0.014	0.010

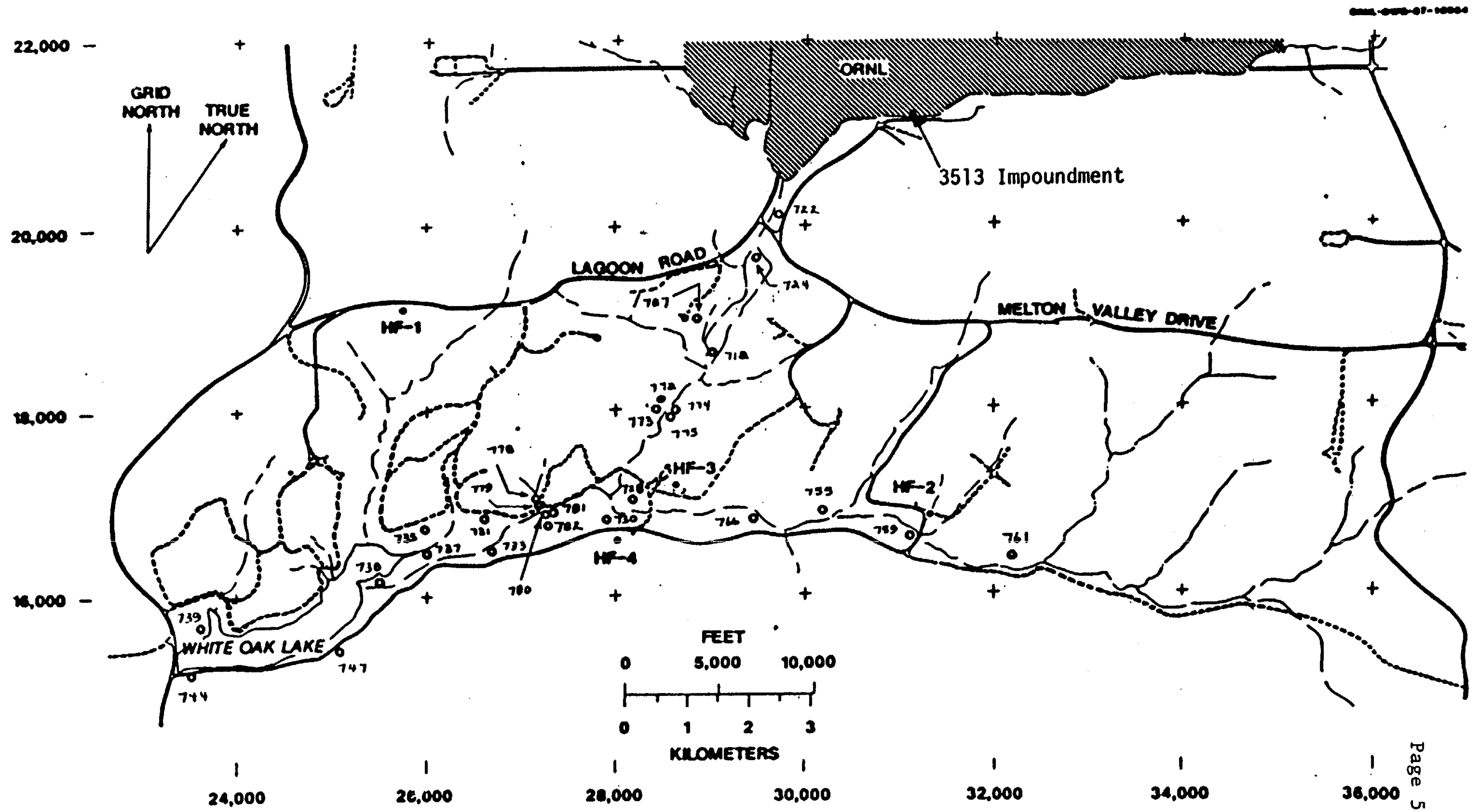


Fig. 20 Piezometers wells sampled for chemical analysis of water in the White Oak Creek Floodplain.

Table 11. Groundwater constituent concentrations measured in shallow piezometers in the White Oak Creek Floodplain[a] (McCrackin et al. 1987). (in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0712	0722	0724	0728
CL	15	14	4.2	14
F	< 1	< 1	< 1	< 1
NO3	< 5	< 5	< 5	< 5
PO4	< 5	< 5	< 5	< 5
SO4	27	< 5	120	22
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	< 0.2	51	1.7	19
AS	< 0.1	< 0.1	< 0.1	< 0.1
B	< 0.08	< 0.08	< 0.08	< 0.08
BA	0.34	2.4	0.23	0.79
BE	< 0.002	0.0094	< 0.002	0.0022
CA	120	69	130	170
CD	< 0.005	0.0095	< 0.005	< 0.005
CO	< 0.01	0.071	0.022	0.034
CR	< 0.04	0.32	0.46	0.052
CU	< 0.02	0.17	< 0.02	0.028
FE	27	77	19	28
GA	< 0.3	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	< 0.2	< 0.2
MG	13	23	16	22
MN	5.1	9.4	13	2.1
MO	< 0.04	< 0.04	< 0.04	< 0.04
NA	27	11	10	13
NI	< 0.06	0.16	0.22	< 0.06
P	< 0.3	0.63	< 0.3	0.93
PB	< 0.2	0.43	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2	< 0.2
SI	4.2	46	4.5	25
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	0.19	0.17	0.24	0.26
TI	< 0.02	< 0.02	< 0.02	< 0.02
V	< 0.01	0.17	0.014	0.043
ZN	< 0.02	0.28	< 0.02	0.092
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	< 0.2	< 0.4	< 0.2	< 0.1
CS-137	0.67	< 0.4	0.32	< 0.1
G-ALPHA	1	.	.	.
G-BETA	120	12	220	1.3
H-3	6600	20	100	150000
SR-90	55	3.4	83	0.049

[a] Unfiltered samples - analytical results for metals may be affected by suspended materials in some samples.

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0730	0731	0733	0735
CL	2.5	1.4	7.5	1.9
F	< 1	< 1	< 1	< 1
NO3	< 1	< 5	< 5	< 5
PO4	< 1	< 5	< 5	< 5
SO4	6	22	18	8.2
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	< 0.2	42	< 0.2	1.7
AS	< 0.1	< 0.1	< 0.1	< 0.1
B	< 0.08	< 0.08	< 0.08	< 0.08
BA	0.044	0.67	0.067	0.21
BE	< 0.002	0.0036	< 0.002	< 0.002
CA	17	130	110	98
CD	< 0.005	0.0058	< 0.005	< 0.005
CO	< 0.01	0.058	< 0.01	< 0.01
CR	< 0.04	0.16	< 0.04	< 0.04
CU	< 0.02	0.036	< 0.02	0.14
FE	0.18	46	1.3	2.1
GA	< 0.3	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	< 0.2	< 0.2
MG	0.99	26	9.2	9
MN	0.052	3.7	1.6	0.4
MO	< 0.04	< 0.04	< 0.04	< 0.04
NA	1.8	14	5.1	5.2
NI	< 0.06	0.11	< 0.06	< 0.06
P	< 0.3	0.46	< 0.3	< 0.3
PB	< 0.2	< 0.2	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2	< 0.2
SI	5.3	47	3.2	7.7
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	0.029	0.19	0.18	0.22
TI	< 0.02	0.044	< 0.02	< 0.02
V	< 0.01	0.08	< 0.01	< 0.01
ZN	< 0.02	0.15	< 0.02	0.07
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	< 0.3	< 0.2	0.14	< 0.1
CS-137	< 0.2	< 0.1	1.5	< 0.1
G-ALPHA	< 2	.	1.2	< 0.2
G-BETA	< 3	1.2	46	1.3
H-3	440	40	1200	56
SR-90	0.14	0.032	21	0.14

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0737	0738	0739	0744
CL	4.2	14	22	3
F	< 1	< 1	< 1	< 1
NO3	< 5	< 5	3.8	< 1
PO4	< 5	< 5	< 1	< 1
SO4	53	45	38	27
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	1.1	4.7	0.84	1
AS	< 0.1	< 0.1	< 0.1	< 0.1
B	< 0.08	< 0.08	< 0.08	< 0.08
BA	0.053	0.23	0.15	0.21
BE	< 0.002	< 0.002	< 0.002	< 0.002
CA	69	150	23	160
CD	< 0.005	< 0.005	< 0.005	< 0.005
CO	< 0.01	0.015	< 0.01	< 0.01
CR	< 0.04	0.069	< 0.04	< 0.04
CU	< 0.02	0.035	< 0.02	< 0.02
FE	1.1	8.1	1.1	1.6
GA	< 0.3	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	< 0.2	< 0.2
MG	8.3	16	5.8	17
MN	0.18	12	0.47	0.077
MO	< 0.04	< 0.04	< 0.04	< 0.04
NA	52	45	16	7.5
NI	< 0.06	0.068	< 0.06	< 0.06
P	< 0.3	0.3	< 0.3	< 0.3
PB	< 0.2	< 0.2	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2	< 0.2
SI	3.1	8	3.4	6.7
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	0.13	0.27	0.068	0.32
TI	< 0.02	< 0.02	0.026	0.032
V	< 0.01	< 0.01	< 0.01	< 0.01
ZN	< 0.02	0.13	< 0.02	< 0.02
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	1.9	2.3	< 0.2	< 0.3
CS-137	3.9	12	< 0.1	< 0.3
G-ALPHA	.	.	2.3	< 2
G-BETA	34	20	< 3	< 3
H-3	1000	4200	61	100
SR-90	6.4	2.7	0.13	< 0.05

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0747	0755	0759	0761
CL	1.3	11	1.4	8.8
F	< 1	< 1	< 1	< 1
NO3	< 5	< 5	< 1	< 5
PO4	< 5	< 5	< 1	< 5
SO4	7.6	14	12	24
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	16	5.8	< 0.20	2
AS	< 0.1	< 0.1	< 0.10	< 0.1
B	< 0.08	0.12	0.19	< 0.08
BA	0.67	0.18	0.50	0.09
BE	< 0.002	< 0.002	< 0.002	< 0.002
CA	100	76	66.	12
CD	< 0.005	< 0.005	< 0.005	< 0.005
CO	0.03	0.012	< 0.010	< 0.01
CR	0.13	0.048	< 0.040	< 0.04
CU	0.081	0.27	< 0.020	< 0.02
FE	23	9.8	0.35	1.8
GA	< 0.3	< 0.3	< 0.30	< 0.3
LI	< 0.2	< 0.2	< 0.20	< 0.2
MG	16	12	18.	2.9
MN	0.99	3.8	0.12	1.3
MO	< 0.04	< 0.04	< 0.040	< 0.04
NA	8.2	19	29.	11
NI	0.081	< 0.06	< 0.060	< 0.06
P	0.33	< 0.3	< 0.30	< 0.3
PB	< 0.2	< 0.2	< 0.20	< 0.2
SB	< 0.2	< 0.2	< 0.20	< 0.2
SE	< 0.2	< 0.2	< 0.20	< 0.2
SI	25	9.9	7.9	5.2
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	0.19	0.23	1.3	0.033
TI	0.073	0.12	< 0.020	0.023
V	0.044	< 0.01	< 0.01	< 0.01
ZN	0.082	0.12	< 0.02	< 0.02
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	< 0.2	< 0.2	< 0.3	< 0.1
CS-137	< 0.2	0.9	0.55	< 0.1
G-ALPHA	.	1	2.6	< 1
G-BETA	0.6	14	4.6	1
H-3	25	120000	29	95
SR-90	0.004	7.5	0.16	0.21

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANSLYSIS	WELL NO. 0766	0772	0773	0774
CL	83	2.2	2.8	2.6
F	< 1	< 1	< 1	< 1
NO3	< 1	< 5	< 5	< 5
PO4	< 1	< 5	< 5	< 5
SO4	8	21	130	16
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	0.38	2.6	0.24	4.1
AS	< 0.1	< 0.1	< 0.1	< 0.1
B	< 0.08	< 0.08	0.23	< 0.08
BA	0.38	0.26	0.086	0.17
BE	< 0.002	< 0.002	< 0.002	< 0.002
CA	83	110	63	58
CD	< 0.005	< 0.005	< 0.005	< 0.005
CO	< 0.01	< 0.01	< 0.01	< 0.01
CR	< 0.04	0.1	< 0.04	0.077
CU	< 0.02	< 0.02	< 0.02	< 0.02
FE	0.58	4.1	0.28	22
GA	< 0.3	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	< 0.2	< 0.2
MG	11	13	36	8.3
MN	0.12	0.91	0.1	3.3
MO	< 0.04	< 0.04	< 0.04	< 0.04
NA	9.9	9.8	100	4.9
NI	< 0.06	< 0.06	< 0.06	< 0.06
P	< 0.3	< 0.3	< 0.3	< 0.3
PB	< 0.2	< 0.2	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2	< 0.2
SI	8.6	7.7	8.9	7.8
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	0.23	0.22	3.2	0.14
TI	< 0.02	0.025	0.025	< 0.02
V	< 0.01	< 0.01	< 0.02	0.012
ZN	< 0.02	< 0.02	< 0.02	< 0.02
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	< 0.1	< 0.1	.	< 0.2
CS-137	< 0.1	< 0.1	.	< 0.2
G-ALPHA	< 2	.	.	.
G-BETA	6	0.6	.	1.9
H-3	150000	120	.	160
SR-90	0.1	0.093	.	0.55

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0775	0778	0779	0780
CL	1	1.5	42	16
F	< 1	< 1	< 1	< 1
NO3	< 5	< 1	< 1	< 1
PO4	< 5	< 1	< 1	< 1
SO4	29	63	52	40
AG	< 0.05	< 0.05	< 0.05	< 0.05
AL	0.88	< 0.2	< 0.2	< 0.2
AS	< 0.1	< 0.1	< 0.1	< 0.1
B	0.24	< 0.08	< 0.08	0.1
BA	0.25	0.053	0.064	0.063
BE	< 0.002	< 0.002	< 0.002	< 0.002
CA	64	98	59	73
CD	< 0.005	< 0.005	< 0.005	< 0.005
CO	< 0.01	< 0.01	< 0.01	< 0.01
CR	< 0.04	< 0.04	< 0.04	< 0.04
CU	< 0.02	< 0.02	< 0.02	< 0.02
FE	1.4	0.27	0.036	0.12
GA	< 0.3	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	< 0.2	< 0.2
MG	22	21	32	12
MN	0.33	0.087	0.014	0.36
MO	< 0.04	< 0.04	< 0.04	< 0.04
NA	64	8.4	15	39
NI	< 0.06	< 0.06	< 0.06	< 0.06
P	< 0.3	< 0.3	< 0.3	< 0.3
PB	< 0.2	< 0.2	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2	< 0.2
SI	9.4	9.8	12	3.6
SN	< 0.05	< 0.05	< 0.05	< 0.05
SR	1.6	0.28	1.7	0.54
TI	0.021	< 0.02	< 0.02	< 0.02
V	< 0.02	< 0.01	< 0.01	< 0.01
ZN	< 0.02	< 0.02	< 0.02	< 0.02
ZR	< 0.02	< 0.02	< 0.02	< 0.02
CO-60	.	< 0.2	< 0.2	< 0.1
CS-137	.	< 0.2	< 0.2	0.43
G-ALPHA	.	< 2	< 1	< 2
G-BETA	.	< 3	< 3	7
H-3	.	170	59	210
SR-90	.	0.1	0.1	2.7

Table 11. (continued)

(in mg/L except radiological concentrations, which are in BQ/L

ANALYSIS	WELL NO. 0781	0782	0787
CL	200	44	57
F	1.3	< 1	< 1
NO3	< 5	< 1	< 5
PO4	< 5	< 1	< 5
SO4	13	17	75
AG	< 0.05	< 0.05	< 0.05
AL	2.1	< 0.2	0.66
AS	< 0.1	< 0.1	< 0.1
B	0.42	0.17	1.5
BA	0.24	0.21	0.13
BE	< 0.002	< 0.002	< 0.002
CA	29	64	110
CD	< 0.005	< 0.005	< 0.005
CO	< 0.01	< 0.01	0.027
CR	< 0.04	< 0.04	< 0.04
CU	< 0.02	< 0.02	< 0.02
FE	3	0.094	1.6
GA	< 0.3	< 0.3	< 0.3
LI	< 0.2	< 0.2	0.23
MG	6.1	11	22
MN	0.18	0.053	11
MO	< 0.04	< 0.04	< 0.04
NA	250	16	35
NI	< 0.06	< 0.06	< 0.06
P	< 0.3	< 0.3	< 0.3
PB	< 0.2	< 0.2	< 0.2
SB	< 0.2	< 0.2	< 0.2
SE	< 0.2	< 0.2	< 0.2
SI	8.3	8.3	3.4
SN	< 0.05	< 0.05	< 0.05
SR	0.75	1.1	0.19
TI	0.034	< 0.02	< 0.02
V	< 0.02	< 0.01	< 0.01
ZN	< 0.02	< 0.02	< 0.02
ZR	< 0.02	< 0.02	< 0.02
CO-60	.	< 0.2	< 0.1
CS-137	.	< 0.2	< 0.1
G-ALPHA	.	< 1	1
G-BETA	.	1.6	190
H-3	.	< 30	14000
SR-90	.	0.1	93

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APPENDIX A

HYDROLOGIC DATA

Table 1A. Daily precipitation at sites in the White Oak Creek watershed and Oak Ridge.

a. 49 Trench site (SWSA 6)

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	2.50	5.10	0.00	8.90	0.00	0.00	4.57	3.04	0.00	0.25	0.00
2	0.00	0.00	26.70	0.00	25.40	0.00	0.00	8.14	0.00	9.92	0.00	6.12
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.20
4	0.00	0.00	0.00	0.00	1.90	0.00	4.10	0.00	0.00	0.00	0.00	0.00
5	0.00	12.70	0.00	0.00	0.00	0.00	0.80	0.12	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	3.50	0.00	0.00	14.20	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	1.00	28.64	0.00	0.00	2.16	0.00
9	0.00	7.60	0.00	0.00	0.00	3.20	9.20	43.20	3.06	0.00	9.15	0.00
10	0.00	0.00	8.90	7.30	0.00	19.40	0.00	3.96	1.90	0.00	0.00	0.00
11	0.00	0.60	1.90	13.30	0.00	0.00	19.80	11.42	0.00	0.00	4.06	5.08
12	0.00	1.30	0.00	1.90	10.80	22.50	0.00	0.51	0.00	0.00	1.01	3.04
13	0.00	0.00	13.30	0.00	0.00	18.70	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	7.60	0.00	0.00	6.40	3.80	0.00	4.60	4.57	0.00	7.61
15	0.00	0.00	0.00	0.00	0.00	0.00	3.10	0.00	1.71	3.20	0.00	19.68
16	0.00	0.00	0.00	1.30	7.60	0.00	0.00	0.00	0.00	21.18	3.43	8.63
17	0.00	0.00	0.00	0.40	0.00	0.00	0.00	10.00	3.69	2.54	0.00	0.50
18	8.30	0.00	0.00	0.00	0.00	0.00	0.00	1.44	51.79	2.55	16.26	0.00
19	0.60	0.00	0.00	0.00	2.90	0.00	0.00	0.00	15.63	0.00	12.19	0.00
20	1.60	0.00	0.00	26.70	0.00	0.00	12.00	0.00	0.00	3.05	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00
22	0.00	0.00	0.00	0.00	.	0.00	0.00	0.00	10.93	20.93	0.00	0.00
23	19.10	0.00	0.00	0.00	.	0.00	11.20	7.89	0.00	0.00	0.00	0.00
24	17.20	0.00	0.00	0.00	0.00	8.90	12.90	0.52	0.51	0.00	7.38	3.30
25	3.80	0.00	0.00	0.00	0.00	42.90	5.30	0.00	21.84	0.00	0.76	0.00
26	8.30	0.00	0.00	40.60	0.00	0.00	10.90	0.00	0.00	13.40	0.00	0.00
27	1.90	1.90	1.30	19.10	0.00	0.00	0.00	0.00	2.03	25.20	2.79	0.64
28	12.60	0.60	0.00	11.40	0.00	0.00	0.00	0.00	0.00	21.34	0.00	0.00
29	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	.	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	.	15.76	1.27
31	0.00	.	6.40	2.50	.	0.00	.	0.00	0.00	.	0.00	.
TOTAL	73.40	27.20	71.20	128.00	58.80	122.00	108.80	120.41	120.73	128.77	75.20	69.07

Table 1A. (continued)

b. ETF Site (SWSA 6)

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	1.90	5.10	0.00	8.90	0.00	0.80	5.86	2.78	0.00	0.76	0.00
2	0.00	0.00	26.00	0.00	25.40	0.00	0.00	7.12	0.00	9.88	0.00	6.49
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.10
4	0.00	0.00	0.00	0.00	2.50	0.00	2.50	0.00	0.00	0.00	0.00	0.00
5	0.00	12.70	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	4.40	0.00	0.00	14.60	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	2.50	1.30	27.96	0.00	0.00	2.55	0.00
9	0.00	5.70	0.00	0.00	0.00	3.80	9.20	50.04	3.06	0.00	9.65	0.00
10	0.00	0.00	8.30	17.80	0.00	16.50	0.00	3.85	2.02	0.00	0.00	0.00
11	0.00	0.00	1.30	7.60	0.00	1.30	18.30	13.17	0.00	0.00	4.84	5.34
12	0.00	2.50	0.00	0.00	10.80	22.20	0.00	0.00	0.00	0.00	0.62	3.05
13	0.00	0.00	12.10	0.00	0.00	19.40	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	6.40	0.00	0.00	5.70	3.80	0.00	4.33	4.84	0.00	8.01
15	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	2.52	3.19	0.00	21.08
16	0.00	0.00	0.00	2.50	8.90	0.00	0.00	0.00	0.00	20.05	2.79	9.41
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.92	3.59	3.79	0.00	0.89
18	7.60	0.00	0.00	0.00	0.00	0.00	0.00	2.90	52.15	1.26	17.55	0.00
19	0.60	0.00	0.00	0.00	3.80	0.00	0.00	0.00	17.17	0.00	9.90	0.00
20	1.30	0.00	0.00	25.40	0.00	0.00	12.40	0.00	0.00	3.05	0.00	0.00
21	0.00	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.18	20.57	0.00	0.00
23	19.70	0.00	0.00	0.00	3.20	0.00	10.90	7.64	0.00	0.00	0.00	0.00
24	20.30	0.00	0.00	0.00	0.00	7.90	13.00	1.26	0.51	0.00	7.38	3.56
25	3.20	0.00	0.00	0.00	0.00	43.20	5.60	0.00	22.50	0.00	0.76	0.00
26	8.90	0.00	0.00	43.20	0.00	0.00	10.90	0.00	0.00	11.97	0.00	0.00
27	1.30	3.20	1.30	20.30	0.00	0.00	0.00	0.00	2.29	27.92	2.79	0.76
28	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.08	0.00	0.00
29	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	.	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	15.76	1.52
31	0.00	.	7.60	1.30	.	0.00	.	0.00	0.76	.	0.00	.
TOTAL	76.90	26.00	68.10	124.40	64.80	122.50	108.70	129.72	124.86	128.36	75.35	75.21

Table 1A. (continued)

c. SWSA 5 Site

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	2.03	4.83	0.00	10.41	0.00	0.51	1.27	3.30	0.00	0.51	0.00
2	0.00	0.00	25.65	0.00	23.88	0.00	0.25	9.40	0.00	8.89	0.00	1.52
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54
4	0.00	0.00	0.00	0.00	2.79	0.00	2.03	0.00	0.00	0.00	0.00	5.08
5	0.00	10.92	0.00	0.00	3.56	0.00	2.29	0.00	0.00	0.00	0.00	7.62
6	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	2.03	0.00	0.00	14.48	0.00	0.00	0.00	0.00	0.00
8	0.00	1.52	0.00	1.78	0.25	0.00	1.02	27.18	0.00	0.00	1.52	0.00
9	0.00	14.99	0.00	0.00	0.00	3.05	9.40	44.96	2.29	0.00	10.41	0.00
10	0.00	0.00	13.21	13.97	0.00	11.94	0.00	2.79	1.02	0.00	0.00	0.00
11	0.00	0.00	3.05	9.40	0.00	5.59	18.54	12.19	0.76	0.00	3.30	0.00
12	0.00	1.27	0.00	0.00	10.16	21.34	0.00	0.76	0.00	0.00	1.52	4.83
13	0.51	0.00	24.38	0.00	0.00	18.03	0.00	0.00*	0.00	0.00	0.00	3.05
14	0.00	0.00	12.70	0.00	0.00	5.33	1.78	0.00	3.05	4.83	0.00	7.62
15	0.00	0.00	0.00	0.00	0.00	0.00	4.83	0.00	3.30	2.79	0.00	17.27
16	0.00	0.00	0.00	3.30	5.33	0.00	0.51	0.00	0.00	20.83	3.05	9.40
17	0.00	0.00	0.00	0.25	0.00	0.00	0.51	7.11	0.00	2.79	0.00	0.51
18	5.84	0.00	0.00	0.00	0.00	0.00	0.00	4.83	34.04	2.03	17.27	0.00
19	0.25	0.00	0.00	0.00	2.03	0.00	0.00	0.00	38.61	0.00	1.02	0.00
20	1.27	0.00	0.00	38.61	0.00	0.00	10.41	0.00	0.00	2.03	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.40*	20.07	0.00	0.00
23	19.56	0.00	0.00	0.00	3.56	0.00	11.18	6.86	0.00	0.00	0.00	0.00
24	11.43	0.00	0.00	0.00	0.00	6.60	12.95	1.27	0.00	0.00	6.10	2.79
25	4.06	0.00	0.00	0.00	0.00	47.50	5.84	0.00	25.40*	0.00	0.76	0.00
26	8.13	0.00	0.00	29.97	0.00	0.25	10.67	0.00	0.00	11.94	0.00	0.00
27	2.03	0.76	0.00	18.54	0.00	0.00	0.00	0.00	1.52*	27.69	2.03	0.25
28	12.70	0.51	0.00	10.16	0.00	0.00	0.00	0.00	1.27	21.08	0.00	0.00
29	0.00	2.03	0.00	0.00	1.78	0.00	0.00	0.00	0.00*	.	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	.	14.48	0.25
31	0.00	.	5.59	1.02	.	0.00	.	0.00	0.00	.	0.00	.
TOTAL	65.78	34.03	89.41	129.03	63.75	119.63	107.70	118.62	124.21	125.73	61.97	62.73

* Data taken from U.S. Weather Bureau in Oak Ridge due to data loss at USGS station.

Table 1A. (continued)

d. Tower C Site

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	*	*	*	*	*	*	*	*	.	.	.	.
2	*	*	*	*	*	*	*	*	0.00	7.62	0.00	.
3	*	*	*	*	*	*	*	*	0.00	0.00	0.00	.
4	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
5	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
6	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
7	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
8	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
9	*	*	*	*	*	*	*	*	0.00	0.00	7.62	0.00
10	*	*	*	*	*	*	*	*	2.54	0.00	2.54	.
11	*	*	*	*	*	*	*	*	0.00	0.00	0.00	5.08
12	*	*	*	*	*	*	*	*	-0.00	0.00	2.54	2.54
13	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
14	*	*	*	*	*	*	*	*	2.54	2.54	0.00	10.16
15	*	*	*	*	*	*	*	*	2.54	2.54	0.00	17.78
16	*	*	*	*	*	*	*	*	0.00	20.32	2.54	10.16
17	*	*	*	*	*	*	*	*	.	0.00	0.00	0.00
18	*	*	*	*	*	*	*	*	.	0.00	17.78	0.00
19	*	*	*	*	*	*	*	*	.	0.00	2.54	0.00
20	*	*	*	*	*	*	*	*	0.00	2.54	0.00	0.00
21	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
22	*	*	*	*	*	*	*	*	10.16	17.78	0.00	0.00
23	*	*	*	*	*	*	*	*	0.00	0.00	0.00	0.00
24	*	*	*	*	*	*	*	*	0.00	0.00	5.08	5.08
25	*	*	*	*	*	*	*	*	15.24	0.00	0.00	.
26	*	*	*	*	*	*	*	*	0.00	12.70	0.00	0.00
27	*	*	*	*	*	*	*	*	2.54	25.40	2.54	0.00
28	*	*	*	*	*	*	*	*	0.00	22.86	0.00	0.00
29	*	*	*	*	*	*	*	*	0.00	.	0.00	0.00
30	*	*	*	*	*	*	*	*	0.00	.	15.24	0.00
31	*	*	*	*	*	*	*	*	0.00	.	0.00	.
TOTAL	*	*	*	*	*	*	*	*	35.56	114.30	58.42	50.80

* Data not available before February, 1987.

Table 1A. (continued)

e. Pits and trenches sites (TR 7)

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	2.28	5.34	0.00	9.92	0.00	1.27	3.79	2.80	0.00	0.50	0.00
2	0.00	0.00	25.15	0.00	22.35	0.00	0.00	6.85	0.00	8.15	0.00	6.49
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.60
4	0.00	0.00	0.00	0.00	2.79	0.00	3.82	0.00	0.00	0.00	0.00	0.00
5	0.00	13.34	0.00	0.00	0.76	0.00	1.26	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	4.83	0.00	0.00	14.72	0.00	0.00	0.00	0.00	0.00
8	0.00	1.02	0.00	0.00	0.00	0.00	1.27	27.94	0.00	0.00	2.15	0.00
9	0.00	12.83	0.00	0.00	0.00	3.30	9.65	41.41	3.04	0.00	10.66	0.00
10	0.00	0.00	12.44	18.07	0.00	15.03	0.00	3.59	0.76	0.00	0.00	0.00
11	0.00	0.00	2.80	7.20	0.00	2.37	19.05	11.63	1.52	0.00	4.33	5.34
12	0.00	1.02	0.00	0.00	10.04	23.00	0.00	1.02	0.00	0.00	0.25	3.17
13	0.00	0.00	24.00	0.00	0.00	18.03	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	11.42	0.00	0.00	6.22	4.06	0.00	4.65	5.34	0.00	7.88
15	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	2.27	2.57	0.00	18.55
16	0.00	0.00	0.00	3.29	6.35	0.00	0.00	0.00	0.00	21.82	3.55	10.79
17	0.00	0.00	0.00	0.25	0.25	0.00	0.00	9.42	1.81	1.78	0.00	0.51
18	6.86	0.00	0.00	0.00	0.00	0.00	0.00	2.26	38.56	1.77	16.76	0.00
19	0.51	0.00	0.00	0.00	2.80	0.00	0.00	0.00	30.47	0.00	2.03	0.00
20	1.52	0.00	0.00	32.65	0.00	0.00	11.71	0.00	0.00	2.80	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.41	19.95	0.00	0.00
23	18.80	0.00	0.00	0.00	3.56	0.00	11.76	7.15	0.00	0.00	0.00	0.00
24	13.21	0.00	0.00	0.00	0.00	9.51	12.35	0.47	0.00	0.00	6.22	3.68
25	3.81	0.00	0.00	0.00	0.00	42.80	5.07	0.00	20.59	0.00	0.76	0.00
26	7.48	0.00	0.00	32.27	0.00	0.00	10.67	0.00	0.00	13.08	0.00	0.00
27	1.68	0.76	0.00	19.05	0.00	0.00	0.00	0.00	1.77	26.43	2.54	0.76
28	12.46	1.02	0.00	10.68	0.00	0.00	0.00	0.00	0.00	20.83	0.00	0.00
29	0.00	1.02	0.00	0.00	1.77	0.00	0.00	0.00	0.00	.	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	.	15.24	0.63
31	0.00	.	6.35	1.02	.	0.00	.	0.00	0.00	.	0.00	.
TOTAL	66.33	33.29	87.50	130.07	60.59	120.26	110.97	115.53	118.45	125.16	64.99	73.40

Table 1A. (continued)

f. Center 7 Site (SW 7)

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	0.90	4.32	0.00	8.90	0.00	0.51	4.06	3.05	0.00	0.76	0.00
2	0.00	0.00	24.13	0.00	26.43	0.00	0.00	5.82	0.00	8.89	0.00	6.12
3	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.51	0.00	0.00	0.00	13.20
4	0.00	0.00	0.00	0.00	1.78	0.25	3.81	0.00	0.00	0.00	0.00	0.00
5	0.00	9.14	0.00	0.00	8.62	0.00	1.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	4.83	0.00	0.00	15.76	0.00	0.00	0.00	0.00	0.00
8	0.00	0.51	0.00	0.00	0.00	0.00	1.27	27.65	0.00	0.00	1.78	0.00
9	0.00	17.15	0.00	0.00	0.00	3.57	9.91	46.01	3.30	0.00	8.64	0.00
10	0.00	0.00	16.25	17.28	0.00	10.50	0.00	3.59	1.78	0.00	0.00	0.00
11	0.00	0.00	8.13	5.08	0.00	7.29	19.42	11.63	0.25	0.00	4.31	5.08
12	0.00	1.27	0.00	0.00	9.91	20.34	0.00	1.02	0.00	0.00	0.50	3.30
13	0.00	0.00	22.35	0.00	0.00	18.83	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	10.92	0.00	0.00	7.81	3.81	0.00	5.08	5.60	0.00	8.14
15	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	1.51	3.64	0.00	19.57
16	0.00	0.00	0.00	1.14	6.60	0.00	0.25	0.00	0.00	20.61	4.06	9.40
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.42	2.29	3.44	0.00	0.51
18	4.07	0.00	0.00	0.00	0.00	0.00	0.00	2.26	50.10	1.77	18.28	0.00
19	0.25	0.00	0.00	2.29	1.90	0.00	0.00	0.00	20.98	0.00	0.25	0.00
20	1.52	0.00	0.00	16.39	0.00	0.00	9.89	0.00	0.00	1.91	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.76	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.78	20.06	0.00	0.00
23	22.49	0.00	0.00	0.00	3.80	0.00	11.46	7.95	0.00	0.00	0.00	0.00
24	9.91	0.00	0.00	0.00	0.00	6.18	12.14	0.42	0.00	0.00	5.84	3.68
25	3.94	0.00	0.00	0.00	0.00	45.86	5.08	0.00	20.34	0.00	1.02	0.00
26	10.53	0.00	0.00	22.59	0.00	0.00	10.15	0.00	0.63	14.57	0.00	0.00
27	0.00	2.03	0.64	14.73	0.00	0.00	0.00	0.00	1.65	24.80	1.52	0.76
28	12.70	1.27	0.00	10.41	0.00	0.00	0.00	0.00	0.00	20.07	0.00	0.00
29	0.00	10.92	0.00	0.00	2.80	0.00	0.00	0.00	0.00	.	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	15.51	0.63
31	0.00	.	7.36	2.31	.	0.00	.	0.00	0.00	.	0.00	.
TOTAL	65.41	43.19	94.10	97.81	71.24	120.63	106.98	120.34	122.26	126.12	62.47	70.39

Table 1A. (continued)

g. White Oak Dam

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	2.79	.	0.00	.	0.00	1.02	5.33	3.05	0.00	0.76	0.00
2	0.00	0.25	.	0.25	.	0.00	0.00	6.86	0.25	9.65	0.00	5.84
3	0.00	0.00	.	0.00	0.25	0.00	0.25	0.25	0.00	0.25	0.00	17.27
4	0.00	0.00	.	0.00	2.54	0.25	3.30	0.00	0.00	0.00	.	0.00
5	0.00	9.65	.	0.00	0.00	0.00	1.27	0.00	.	0.00	.	0.00
6	0.00	0.76	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	.	2.54	0.00	0.00	14.48	0.00	0.00	0.00	0.00	0.00
8	0.00	0.51	.	2.29	0.25	0.00	1.78	28.19	0.00	0.00	2.29	0.00
9	0.00	4.83	.	0.00	0.00	3.30	9.65	42.93	2.79	0.00	8.89	0.00
10	.	0.00	.	0.76	0.00	13.46	0.00	3.05	1.02	0.00	.	0.00
11	.	0.00	.	13.21	0.00	3.30	18.29	11.43	1.02	0.76	4.06	5.59
12	0.00	1.52	.	11.43	11.18	22.35	0.25	.	0.00	0.00	0.76	3.56
13	0.51	.	.	0.00	.	19.56	0.00	.	0.00	0.25	0.00	0.00
14	0.00	0.00	.	0.00	.	5.84	3.56	.	.	4.57	0.00	12.95
15	0.00	0.00	.	0.00	.	0.00	3.05	.	.	2.54	0.00	9.40
16	0.00	0.00	.	2.03	.	0.00	0.51	.	.	21.08	4.06	9.91
17	0.00	0.00	0.00	0.51	.	0.00	0.00	9.14	1.27	2.54	0.00	0.76
18	6.35	.	0.00	0.00	.	0.00	0.00	.	35.81	2.29	17.27	0.00
19	1.02	.	0.00	0.00	3.56	.	0.00	0.00	33.53	0.00	10.92	0.00
20	1.78	.	0.00	41.66	0.00	0.00	11.94	0.00	0.00	2.29	0.00	0.00
21	0.00	.	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.76	0.00	0.00
22	0.00	.	0.00	0.00	0.00	0.00	.	0.00	11.18	20.32	0.00	0.00
23	21.84	.	.	0.00	3.05	2.03	.	8.13	0.00	0.00	0.00	0.00
24	19.30	.	0.76	0.00	0.00	6.86	13.21	0.76	0.00	0.00	6.60	3.30
25	3.30	.	0.00	0.00	0.00	42.93	5.33	0.00	22.35	0.00	1.02	0.00
26	8.13	.	0.00	58.17	0.00	0.25	10.92	0.00	1.78	11.43	0.00	0.00
27	1.78	.	0.76	37.59	0.00	0.00	0.00	0.00	0.25	26.16	2.54	0.25
28	12.45	.	0.00	11.68	0.00	0.00	0.00	0.00	3.81	21.08	0.00	1.78
29	0.00	.	0.00	0.00	2.03	0.00	0.25	0.00	0.00	.	0.00	.
30	0.00	.	0.00	0.00	0.00	0.25	0.51	0.25	0.00	.	15.75	2.29
31	0.00	.	8.38	2.03	.	0.00	.	0.00	0.00	.	0.25	.
TOTAL	76.46	20.31	9.90	184.40	22.86	120.63	99.57	116.32	118.11	125.97	75.17	72.90

Table 1A. (continued)

h. Oak Ridge Townsite (ATDL)

(precipitation in mm)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.00	14.48	1.52	0.00	13.97	3.30	0.51	6.60	2.54	0.00	1.27	0.00
2	0.00	0.76	25.40	0.00	32.77	0.00	0.00	8.13	1.27	7.37	0.00	7.37
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	7.62
4	0.00	0.25	0.00	0.00	1.27	0.00	4.06	0.00	0.00	0.00	0.00	0.00
5	0.00	16.51	0.00	0.00	19.81	0.00	2.03	0.00	0.00	0.00	0.00	0.00
6	0.00	0.76	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.25	0.00	0.00	6.10	0.00	0.00	15.75	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	1.27	0.51	0.00	0.00	30.99	0.00	0.00	0.00	0.00
9	0.00	1.52	1.02	0.00	0.00	4.06	13.21	50.29	0.00	0.00	9.65	0.00
10	0.00	0.00	10.92	20.32	0.00	0.00	0.00	1.78	4.32	0.00	0.00	0.00
11	0.00	0.00	0.00	6.35	0.00	5.33	14.22	12.45	0.00	0.00	4.06	3.81
12	0.00	1.27	1.27	0.00	8.89	29.72	0.00	0.51	0.00	0.00	0.51	1.78
13	0.00	0.00	12.70	0.00	0.00	18.03	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	9.91	0.00	0.00	3.81	2.03	0.00	3.30	4.57	0.00	32.26
15	0.00	0.00	0.00	2.03	0.00	0.00	1.78	0.00	3.56	2.79	0.00	1.02
16	0.00	0.00	0.00	3.81	13.21	0.00	1.27	0.00	0.00	23.88	8.38	3.81
17	0.00	0.00	0.00	1.02	0.00	0.00	0.00	11.43	1.52	2.29	0.00	1.27
18	5.08	0.00	0.00	0.51	0.25	0.00	0.00	2.79	33.53	3.81	21.36	0.00
19	0.00	0.00	0.00	0.25	4.57	0.00	0.00	0.00	37.08	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	12.45	0.00	0.00	2.79	0.00	0.00
21	0.00	0.00	0.00	1.27	1.27	0.00	0.00	0.00	0.00	3.30	0.00	0.00
22	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	9.40	23.11	0.00	0.00
23	34.80	0.00	0.00	0.25	0.00	0.00	11.94	8.38	0.00	0.00	0.00	0.00
24	2.54	0.00	0.00	0.00	5.59	11.68	12.70	0.76	0.00	0.00	7.37	10.92
25	3.81	0.00	0.00	0.00	0.00	38.61	0.00	0.00	25.40	0.00	0.76	0.00
26	12.95	0.00	0.00	11.43	0.00	0.00	0.00	0.00	0.00	12.19	0.00	0.00
27	0.51	0.00	0.00	6.86	8.89	0.00	0.00	0.00	1.52	32.26	0.00	0.00
28	9.65	0.00	0.51	7.37	0.00	0.00	0.00	0.00	0.00	24.89	0.00	0.00
29	0.00	1.27	0.00	0.00	8.13	0.00	0.00	0.00	0.25	.	0.00	0.00
30	0.00	0.00	0.00	0.25	0.00	0.00	1.27	0.25	0.00	.	8.64	0.00
31	0.00	.	8.89	1.27	.	0.00	.	0.00	0.00	.	0.00	.
TOTAL	69.59	36.82	72.14	72.14	119.38	114.56	93.22	135.12	123.69	143.25	61.98	69.86

Table 2A. Daily discharge at sites in White Oak Creek and its tributaries.

a. First Creek (GS1)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	*	*	*	*	*	*	*	*	*	*	3.67	0.70
2	*	*	*	*	*	*	*	*	*	*	2.29	0.76
3	*	*	*	*	*	*	*	*	*	*	1.73	1.14
4	*	*	*	*	*	*	*	*	*	*	1.38	1.04
5	*	*	*	*	*	*	*	*	*	0.70	1.22	1.13
6	*	*	*	*	*	*	*	*	*	0.67	1.04	1.20
7	*	*	*	*	*	*	*	*	*	0.64	0.97	1.14
8	*	*	*	*	*	*	*	*	*	0.63	0.92	1.09
9	*	*	*	*	*	*	*	*	*	0.59	1.07	0.99
10	*	*	*	*	*	*	*	*	*	0.54	0.83	0.92
11	*	*	*	*	*	*	*	*	*	0.51	0.76	0.90
12	*	*	*	*	*	*	*	*	*	0.50	0.75	0.83
13	*	*	*	*	*	*	*	*	*	0.48	0.67	0.71
14	*	*	*	*	*	*	*	*	*	0.53	0.66	0.89
15	*	*	*	*	*	*	*	*	*	0.50	0.66	2.44
16	*	*	*	*	*	*	*	*	*	1.77	0.72	1.38
17	*	*	*	*	*	*	*	*	*	1.22	0.63	1.73
18	*	*	*	*	*	*	*	*	*	1.25	1.20	1.43
19	*	*	*	*	*	*	*	*	*	1.09	1.28	1.25
20	*	*	*	*	*	*	*	*	*	1.03	1.12	1.07
21	*	*	*	*	*	*	*	*	*	1.00	1.05	0.97
22	*	*	*	*	*	*	*	*	*	2.03	0.93	0.89
23	*	*	*	*	*	*	*	*	*	1.97	0.93	0.81
24	*	*	*	*	*	*	*	*	*	1.54	0.92	0.81
25	*	*	*	*	*	*	*	*	*	1.32	0.86	0.66
26	*	*	*	*	*	*	*	*	*	1.35	0.75	0.61
27	*	*	*	*	*	*	*	*	*	5.21	0.71	0.57
28	*	*	*	*	*	*	*	*	*	5.35	0.67	0.56
29	*	*	*	*	*	*	*	*	*	.	0.63	0.52
30	*	*	*	*	*	*	*	*	*	.	1.00	0.53
31	*	*	*	*	*	*	*	*	*	.	0.77	.
TOTAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.42	32.84	30.13
MEAN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	1.06	1.01
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.63	0.52
MAX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.35	3.67	2.44

* Data not available before February 1987.

Table 2A. (continued)

b. Melton Branch near Melton Hill (GS2)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.05	0.02	0.01	0.00	0.00	0.00	0.02	0.16	0.16	0.38	3.50	0.54
2	0.04	0.02	0.07	0.00	0.01	0.00	0.01	0.32	0.13	0.75	1.70	0.51
3	0.03	0.01	0.03	0.00	0.01	0.00	0.01	0.27	0.10	0.66	1.13	0.93
4	0.03	0.01	0.02	0.00	0.00	0.00	0.01	0.13	0.10	0.49	0.34	1.33
5	0.03	0.03	0.01	0.00	0.00	0.00	0.02	0.13	0.10	0.41	0.65	1.37
6	0.03	0.03	0.01	0.00	0.01	0.00	0.01	0.12	0.10	0.33	0.53	1.27
7	0.03	0.01	0.01	0.00	0.00	0.00	0.08	0.10	0.10	0.33	0.44	1.04
8	0.02	0.01	0.01	0.00	0.00	0.00	0.17	1.40	0.07	0.30	0.44	0.80
9	0.02	0.09	0.01	0.00	0.00	0.00	0.31	13.20	0.08	0.23	0.21	1.65
10	0.02	0.05	0.01	0.00	0.00	0.00	0.16	3.77	0.12	0.22	0.51	0.52
11	0.02	0.03	0.06	0.00	0.00	0.00	0.86	2.77	0.10	0.21	0.41	0.61
12	0.02	0.02	0.04	0.00	0.00	0.00	0.46	1.62	0.09	0.21	0.51	0.52
13	0.02	0.02	0.10	0.00	0.00	0.05	0.19	0.92	0.07	0.17	0.39	0.40
14	0.02	0.01	0.20	0.00	0.00	0.06	0.12	0.57	0.08	0.23	0.33	0.79
15	0.02	0.01	0.02	0.00	0.00	0.01	0.19	0.41	0.17	0.25	0.33	4.04
16	0.01	0.01	0.01	0.00	0.00	0.01	0.15	0.33	0.13	2.11	0.41	1.01
17	0.01	0.01	0.00	0.00	0.00	0.00	0.12	0.29	0.11	1.47	0.33	1.75
18	0.01	0.01	0.00	0.00	0.00	0.00	0.09	0.99	2.10	1.24	0.36	1.23
19	0.02	0.01	0.00	0.00	0.00	0.00	0.07	0.55	23.22	0.91	1.91	0.91
20	0.02	0.01	0.00	0.00	0.00	0.00	0.27	0.39	2.08	0.71	1.12	0.68
21	0.02	0.00	0.00	0.00	0.00	0.00	0.25	0.29	1.20	0.67	0.73	0.54
22	0.02	0.00	0.00	0.00	0.00	0.00	0.16	0.24	1.02	1.98	0.59	0.42
23	0.11	0.00	0.00	0.00	0.00	0.00	0.23	0.27	0.72	2.61	0.49	0.37
24	0.06	0.00	0.00	0.00	0.00	0.00	1.67	0.42	0.54	1.34	0.43	0.34
25	0.15	0.00	0.00	0.00	0.00	0.95	0.89	0.29	2.97	0.97	0.57	0.26
26	0.07	0.00	0.00	0.00	0.00	0.25	1.77	0.23	2.61	0.79	0.39	0.21
27	0.24	0.00	0.00	0.00	0.00	0.08	0.80	0.21	1.16	9.12	0.38	0.20
28	0.38	0.00	0.00	0.00	0.00	0.04	0.40	0.17	0.98	6.46	0.33	0.19
29	0.12	0.00	0.00	0.00	0.00	0.03	0.26	0.17	0.73	.	0.31	0.14
30	0.05	0.00	0.00	0.00	0.00	0.02	0.19	0.15	0.62	.	0.77	0.12
31	0.03	.	0.00	0.00	.	0.02	.	0.13	0.46	.	0.81	.
TOTAL	1.72	0.42	0.62	0.00	0.03	1.52	9.94	31.06	42.22	35.60	23.15	24.58
MEAN	0.06	0.01	0.02	0.00	0.00	0.05	0.33	1.00	1.36	1.27	0.75	0.82
MIN	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.07	0.17	0.21	0.12
MAX	0.38	0.09	0.20	0.00	0.01	0.95	1.77	13.20	23.22	9.12	3.50	4.04

Table 2A. (continued)

c. White Oak Creek below Melton Valley Drive (GS3)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	6.80	6.30	8.60	7.20	7.40	6.38	6.72	7.74	6.62	8.80	32.73	8.04
2	6.60	6.80	11.00	6.30	14.00	6.87	6.42	9.34	5.90	10.81	20.29	8.92
3	5.80	6.80	7.00	6.70	8.40	6.58	6.52	7.83	6.03	9.58	15.72	11.33
4	5.90	6.40	6.30	6.80	7.90	5.35	6.82	6.88	5.83	8.44	12.39	10.94
5	6.20	8.90	6.40	6.90	9.40	5.73	6.96	6.31	5.97	8.52	11.19	10.30
6	6.30	7.40	6.30	7.20	7.10	5.57	6.50	5.85	5.85	8.29	10.59	11.41
7	6.50	6.80	6.10	6.60	6.40	5.83	9.04	5.72	5.87	7.74	9.77	11.12
8	6.60	6.10	6.20	7.00	6.20	5.92	7.61	15.46	5.95	7.86	9.26	10.73
9	6.40	9.20	6.30	6.30	6.30	6.17	9.37	59.15	5.89	7.49	10.77	9.93
10	6.00	7.40	8.60	6.50	6.50	7.46	7.32	30.12	6.24	7.42	8.80	9.39
11	6.00	6.90	6.70	9.70	6.60	7.81	14.14	25.43	5.80	7.31	8.45	9.36
12	6.40	6.30	6.20	6.70	8.60	9.86	9.41	16.76	5.73	7.59	8.58	9.08
13	6.60	6.60	9.50	6.80	6.40	13.68	8.10	12.47	5.75	7.05	7.94	8.51
14	6.40	6.30	8.80	6.70	6.10	12.04	7.42	10.69	5.97	6.95	7.57	10.39
15	6.50	6.30	7.20	6.60	6.40	7.41	8.00	9.70	6.61	7.10	7.55	23.25
16	6.60	6.30	6.70	6.60	7.40	6.64	7.14	8.94	6.11	17.70	8.62	13.57
17	5.80	6.50	6.60	6.70	6.50	6.36	7.17	9.02	5.99	12.18	7.61	16.43
18	6.80	6.20	7.30	6.70	6.40	5.87	7.02	12.40	17.53	12.05	12.55	14.11
19	6.40	6.00	6.80	7.00	6.60	5.90	6.64	8.99	83.43	10.77	13.54	11.94
20	6.30	6.40	6.80	10.00	6.50	5.96	8.95	8.39	23.83	10.24	11.55	11.12
21	6.10	6.30	7.30	6.90	6.20	6.05	7.56	7.53	16.27	9.77	10.91	10.85
22	6.30	5.80	6.80	7.00	6.50	6.17	6.64	7.34	14.92	15.24	9.75	9.77
23	10.00	6.30	7.20	6.30	6.90	6.22	8.96	8.31	11.31	13.93	9.27	8.82
24	9.30	6.70	6.80	6.30	6.40	6.68	16.51	8.58	10.13	14.71	9.37	9.20
25	8.40	6.30	6.60	6.60	6.30	24.72	11.53	7.57	21.22	12.40	9.17	7.54
26	7.50	6.50	6.60	10.00	6.30	10.02	17.66	6.66	20.08	12.40	8.38	7.36
27	8.90	6.50	6.70	11.00	6.50	8.46	10.56	6.77	15.23	49.44	8.21	7.15
28	12.00	6.40	6.70	9.10	6.20	7.39	8.93	6.63	12.94	46.12	7.53	7.40
29	7.80	7.50	6.90	6.50	6.30	7.28	8.08	6.41	11.11	.	7.12	7.06
30	7.30	6.60	6.60	6.50	6.20	7.39	7.57	6.02	10.74	.	10.53	7.10
31	6.80	.	7.10	6.10	.	7.13	.	6.13	9.39	.	8.77	.
TOTAL	217.30	201.80	221.70	223.80	210.90	241.93	261.32	355.14	380.74	365.90	335.10	318.52
MEAN	7.01	6.73	7.15	7.22	7.03	7.80	8.71	11.46	12.28	13.07	10.81	10.62
MIN	5.80	5.80	6.10	6.10	6.10	5.57	6.42	5.72	5.73	6.95	7.12	7.06
MAX	12.00	9.20	11.00	11.00	14.00	24.72	17.66	59.15	83.43	49.44	32.73	23.25

Table 2A. (continued)

d. White Oak Creek (X14)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	5.85	6.46 *	7.67	7.58	6.72 *	6.64	6.71 *	8.69 *	5.58 *	8.87 *	45.39 *	8.54
2	5.74	6.46 *	9.78	6.70 *	7.83	6.54	6.71 *	8.76	5.58 *	8.87 *	45.39 *	8.06
3	5.13 *	6.65	12.38	6.70 *	17.47	6.78	6.71 *	9.67	5.58 *	11.57	19.91	9.39
4	5.13 *	6.71	6.31 *	6.70 *	9.04	5.88 *	6.00	7.50	5.58 *	8.65	14.99	12.72 *
5	5.13 *	7.18	6.31 *	6.82	9.22	5.88 *	6.99	6.90	5.58 *	7.84	12.47	12.72 *
6	5.23	9.79	6.31 *	6.70	9.13 *	5.88 *	6.76	6.26 *	5.71	8.43	11.43	12.72 *
7	5.54	6.39 *	6.31 *	6.93	9.13 *	6.07	6.68	6.26 *	5.26	8.08 *	10.27 *	12.73
8	6.03	6.39 *	6.31 *	6.84	9.13 *	5.91	8.77 *	6.26 *	5.54	8.08 *	10.27 *	10.80
9	5.23	6.39 *	6.39	7.28 *	6.48	6.44	8.77 *	37.20	4.39	8.08 *	10.27 *	10.61
10	4.98 *	10.35	6.99	7.28 *	6.42	6.20	8.77 *	58.98	5.57 *	6.27	8.53	10.15
11	4.98 *	7.13	9.08	7.28 *	6.93	10.58 *	7.77	25.53	5.57 *	7.33	7.01	8.10 *
12	4.98 *	7.27	8.02 *	7.60	8.36	10.58 *	17.11	26.67	5.57 *	7.06	9.19	8.10 *
13	6.20	6.82	8.02 *	7.26	6.17 *	10.58 *	9.45	13.32 *	5.31	7.46	9.52	8.10 *
14	5.69	6.68 *	8.02 *	5.79	6.17 *	15.66	8.56	13.32 *	5.23	10.84 *	6.63 *	8.79
15	5.69	6.68 *	10.24	6.28	6.17 *	9.08	7.79 *	13.32 *	6.17	10.84 *	6.63 *	20.36
16	6.17	6.68 *	7.16	6.52 *	7.40	7.57	7.79 *	9.10	5.45	10.84 *	6.63 *	17.37
17	6.01 *	7.07	6.76	6.52 *	7.54	7.13	7.79 *	8.53	34.55 *	10.84 *	8.03	15.26 *
18	6.01 *	6.92	7.19	6.52 *	5.66	6.24 *	7.33	11.45	34.55 *	13.85	6.36	15.26 *
19	6.01 *	7.27	6.82 *	6.90	7.72	6.24 *	6.68	10.29	34.55 *	12.22	16.65	15.26 *
20	5.48	6.47	6.82 *	10.01	6.12 *	6.24 *	7.58	8.16 *	46.54	11.20	12.39	15.26 *
21	5.99	7.26 *	6.82 *	7.98	6.12 *	6.20	8.66	8.16 *	21.00	16.59 *	10.05 *	10.32
22	6.22	7.26 *	7.50	6.85	6.12 *	6.98	9.54 *	8.16 *	15.70	16.59 *	10.05 *	8.96
23	10.35	7.26 *	7.02	6.33 *	6.41	5.04	9.54 *	8.01	15.10	16.59 *	10.05 *	8.37
24	8.34 *	7.86	7.49	6.33 *	7.36	4.63	9.54 *	7.85 *	17.27 *	13.35	8.59	8.53
25	8.34 *	7.64	7.06	6.33 *	6.31	16.21 *	15.95	7.85 *	17.27 *	14.59	9.92	7.26 *
26	8.34 *	7.63	6.87 *	6.59	6.20	16.21 *	16.46	7.85 *	17.27 *	14.54	8.18	7.26 *
27	8.34 *	8.12	6.87 *	12.50	6.19 *	16.21 *	15.77	6.57 *	20.47	27.96	7.24	7.26 *
28	9.28	8.20 *	6.87 *	15.94	6.19 *	8.34	8.69 *	6.57 *	14.03	45.39 *	7.50 *	6.17
29	10.34	8.20 *	7.32	7.92	6.19 *	7.30	8.69 *	6.57 *	13.13	.	7.50 *	6.45
30	7.16	8.20 *	6.50	6.72 *	5.76	7.01	8.69 *	5.96	11.11	.	7.50 *	6.12
31	6.46 *	.	8.28	6.72 *	.	6.36	.	5.82	8.87 *	.	9.55	.
TOTAL	200.37	219.39	231.49	230.42	221.66	252.61	272.25	375.54	409.63	358.32	375.19	318.06
MEAN	6.46	7.31	7.47	7.43	7.39	8.15	9.08	12.11	13.21	12.80	12.10	10.60
MIN	4.98	6.39	6.31	5.79	5.66	4.63	6.00	5.82	4.39	6.27	6.36	6.10
MAX	10.35	10.35	12.38	15.94	17.47	16.21	17.11	58.98	46.54	45.39	45.39	20.36

* Represents an averaged value.

Table 2A. (continued)

e. Melton Branch (X13)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	0.68	0.70 *	1.72	0.60	0.50	0.32	0.55 *	2.00 *	0.88 *	0.26 *	19.36 *	2.51
2	0.67	0.70 *	0.77	0.55 *	0.62	0.45	0.55 *	1.01	0.88 *	0.26 *	19.36 *	2.14
3	0.64 *	0.53	1.14	0.55 *	2.00	0.37	0.55 *	1.56	0.88 *	24.52	4.66	2.60
4	0.64 *	0.43	0.45 *	0.55 *	0.54	0.37 *	0.46	1.13	0.88 *	20.72	3.23	4.63 *
5	0.64 *	1.72	0.45 *	0.42	0.65	0.37 *	0.53	0.91	0.83	2.52	2.55	4.63 *
6	0.59	1.41	0.45 *	0.39	0.46 *	0.37 *	0.51	0.82 *	0.84	1.96	2.27	4.63 *
7	0.62	0.37 *	0.45 *	0.48	0.46 *	0.40	0.62	0.82 *	0.63	1.68 *	2.39 *	3.95
8	0.65	0.37 *	0.45 *	0.19	0.46 *	0.39	1.35 *	0.82 *	0.67	1.68 *	2.39 *	2.33
9	0.54	0.37 *	0.45	0.53 *	0.40	0.42	1.35 *	18.98	0.60	1.68 *	2.39 *	2.10
10	0.48 *	1.15	0.48	0.53 *	0.37	0.53	1.35 *	37.69	0.77 *	1.21	2.40	1.76
11	0.48 *	0.60	0.67	0.53 *	0.37	1.12 *	0.99	8.31	0.77 *	1.19	1.66	1.58 *
12	0.48 *	0.54	0.81 *	0.65	0.54	1.12 *	4.29	8.59	0.77 *	1.39	2.43	1.58 *
13	2.21	0.54	0.81 *	0.32	0.37 *	1.12 *	1.45	2.63 *	0.96	1.52	2.54	1.58 *
14	1.27	0.51 *	0.81 *	0.19	0.37 *	1.98	1.01	2.63 *	0.54	3.64 *	1.61 *	1.04
15	0.60	0.51 *	1.30	0.25	0.37 *	1.04	0.81 *	2.63 *	0.79	3.64 *	1.61 *	10.04
16	0.53	0.51 *	0.56	0.29 *	0.46	0.51	0.81 *	1.35	0.88	3.64 *	1.61 *	7.66
17	0.60 *	0.48	0.53	0.29 *	0.45	0.46	0.81 *	1.22	44.79 *	3.64 *	1.93	4.52 *
18	0.60 *	0.63	0.51	0.29 *	0.32	0.47 *	0.70	2.29	44.79 *	5.07	1.42	4.52 *
19	0.60 *	0.39	0.55 *	0.42	0.73	0.47 *	0.63	2.31	44.79 *	3.62	6.79	4.52 *
20	0.67	0.32	0.55 *	1.02	0.63 *	0.47 *	0.70	1.52 *	16.76	2.97	4.59	4.52 *
21	0.65	0.45 *	0.55 *	0.56	0.63 *	0.53	1.32	1.52 *	4.47	5.62 *	2.62 *	2.04
22	0.48	0.45 *	0.39	0.40	0.63 *	0.57	1.56 *	1.52 *	2.36	5.62 *	2.62 *	1.56
23	1.02	0.45 *	0.12	0.40 *	0.43	0.40	1.56 *	1.19	5.12	5.62 *	2.62 *	1.33
24	1.15 *	0.46	0.43	0.40 *	0.51	0.50	1.56 *	1.48 *	7.31 *	6.34	1.70	1.27
25	1.15 *	0.43	0.48	0.40 *	1.11	2.54 *	5.35	1.48 *	7.31 *	3.73	2.31	1.11 *
26	1.15 *	0.36	0.45 *	0.40	0.42	2.54 *	4.27	1.48 *	7.31 *	3.36	1.93	1.11 *
27	1.15 *	0.42	0.45 *	1.30	0.42 *	2.54 *	2.14	1.10 *	31.38	13.38	1.39	1.11 *
28	1.21	1.03 *	0.45 *	1.62	0.42 *	0.73	2.00 *	1.10 *	13.21	19.36 *	1.58 *	0.80
29	1.76	1.03 *	0.46	0.73	0.42 *	0.57	2.00 *	1.10 *	10.82	.	1.58 *	0.74
30	0.79	1.03 *	0.40	0.50 *	0.23	0.53	2.00 *	0.93	2.35	.	1.58 *	0.67
31	0.70 *	.	0.43	0.50 *	.	0.57	.	0.88	0.26 *	.	3.06	.
TOTAL	25.40	18.92	18.52	16.25	16.29	24.77	43.78	113.00	257.60	150.39	111.31	55.33
MEAN	0.82	0.63	0.60	0.52	0.54	0.80	1.46	3.65	8.31	5.37	3.59	2.36
MIN	0.48	0.32	0.12	0.19	0.23	0.32	0.46	0.82	0.26	0.26	1.39	0.67
MAX	2.21	1.72	1.72	1.62	2.00	2.54	5.35	37.69	44.79	24.52	19.36	10.04

* Represents an averaged value.

Table 2A. (continued)

f. White Oak Dam (X15)

(flow in cubic feet per second)

DAY	MAY 86	JUN 86	JUL 86	AUG 86	SEP 86	OCT 86	NOV 86	DEC 86	JAN 87	FEB 87	MAR 87	APR 87
1	7.71	7.97 *	8.12	8.18	7.26 *	6.96	7.57 *	11.39 *	7.10 *	13.09 *	69.07 *	12.87
2	7.15	7.97 *	10.55	6.94 *	8.45	6.99	7.57 *	9.41	7.10 *	13.09 *	69.07 *	10.36
3	6.53 *	6.98	13.52	6.94 *	19.46	7.15	7.57 *	12.32	7.10 *	12.58	22.96	12.56
4	6.53 *	7.29	6.71 *	6.94 *	11.45	16.33 *	6.44	10.41	7.10 *	12.97	16.03	15.33 *
5	6.53 *	7.36	6.71 *	7.24	9.41	16.33 *	7.50	8.99	7.10 *	12.18	15.05	15.33 *
6	6.44	10.20	6.71 *	6.76	9.59 *	16.33 *	7.67	7.44 *	7.02	12.01	13.71	15.33 *
7	6.82	7.59 *	6.71 *	7.15	9.59 *	6.28	7.09	7.44 *	6.44	10.53 *	13.17 *	13.09
8	7.72	7.59 *	6.71 *	7.02	9.59 *	7.23	10.11 *	7.44 *	6.61	10.53 *	13.17 *	11.19
9	6.54	7.59 *	6.84	7.81 *	6.68	6.85	10.11 *	56.18	6.22	10.53 *	13.17 *	11.88
10	5.62 *	11.53	7.47	7.81 *	6.64	6.81	10.11 *	113.42	6.93 *	7.43	11.17	14.02
11	5.62 *	8.42	9.75	7.81 *	7.13	11.70 *	22.87	46.59	6.93 *	8.63	9.48	11.31 *
12	5.62 *	7.89	8.84 *	9.70	8.90	11.70 *	19.26	35.26	6.93 *	8.51	11.38	11.31 *
13	7.72	7.06	8.84 *	7.58	6.97 *	11.70 *	13.43	27.05 *	6.51	9.55	13.54	11.31 *
14	7.91	7.19 *	8.84 *	6.59	6.97 *	18.71	10.99	27.05 *	6.27	12.33 *	9.20 *	10.38
15	7.21	7.19 *	10.58	6.56	6.97 *	13.04	9.42 *	27.05 *	7.19	12.33 *	9.20 *	20.95
16	7.18	7.19 *	8.39	0.59 *	7.86	9.28	9.42 *	12.08	7.33	12.33 *	9.20 *	27.14
17	6.98 *	7.55	7.40	0.59 *	8.60	7.78	9.42 *	11.54	35.14 *	12.33 *	11.45	17.18 *
18	6.98 *	7.55	7.71	0.59 *	5.85	6.68 *	8.59	12.29	35.14 *	17.13	8.97	17.18 *
19	6.98 *	7.66	6.82 *	0.11	8.14	6.68 *	8.29	13.35	35.14 *	13.94	23.44	17.18 *
20	6.05	6.79	6.82 *	0.15	6.63 *	6.68 *	8.18	11.57 *	82.79	12.46	17.00	17.18 *
21	7.06	7.71 *	6.82 *	0.19	6.63 *	6.54	10.83	11.57 *	38.85	20.63 *	11.67 *	13.48
22	6.81	7.71 *	7.89	28.52	6.63 *	7.38	9.98 *	11.57 *	31.61	20.63 *	11.67 *	12.16
23	11.37	7.71 *	7.15	10.71 *	6.59	5.52	9.98 *	10.15	27.71	20.63 *	11.67 *	11.56
24	10.07 *	8.32	7.92	10.71 *	7.38	5.96	9.98 *	10.60 *	22.09 *	21.32	11.77	10.63
25	10.07 *	8.08	7.54	10.71 *	6.89	18.78 *	24.28	10.60 *	22.09 *	16.90	12.34	9.43 *
26	10.07 *	7.98	7.33 *	6.87	6.67	18.78 *	17.34	10.60 *	22.09 *	14.98	12.27	9.43 *
27	10.07 *	8.54	7.33 *	13.80	6.61 *	18.78 *	23.87	8.63 *	30.73	41.34	10.49	9.43 *
28	9.90	9.23 *	7.33 *	17.56	6.61 *	10.17	11.39 *	8.63 *	17.90	69.07 *	10.25 *	7.44
29	12.10	9.23 *	7.78	11.43	6.61 *	8.88	11.39 *	8.63 *	25.70	.	10.25 *	7.94
30	9.45	9.23 *	6.90	7.26 *	5.99	7.95	11.39 *	7.64	24.12	.	10.25 *	7.40
31	7.97 *	.	8.71	7.26 *	.	7.57	.	7.40	13.09 *	.	10.54	.
TOTAL	240.78	240.30	246.74	238.06	239.25	317.52	342.04	579.29	574.13	459.98	503.60	392.96
MEAN	7.77	8.01	7.96	7.68	7.98	10.24	11.40	18.69	18.52	16.43	16.25	13.10
MIN	5.62	6.79	6.71	0.11	5.85	5.52	6.44	7.40	6.27	7.43	8.97	7.40
MAX	12.10	11.53	13.52	28.52	19.46	18.78	24.28	113.42	82.79	69.07	69.07	27.14

* Represents an averaged value.

APPENDIX B

REPORTS CONTAINING HYDROLOGIC DATA AND INFORMATION

ABSTRACTS OF SELECTED RAP REPORTS WHICH CONTAIN HYDROLOGIC DATA OR INFORMATION

1. ORNL/RAP-5, 42 pp. (1987, March), Geochemistry of Formation Waters in the Lower Conasauga Group at the New Hydrofracture Facility: Preliminary Data from the Rock Cover (RC) Wells. Switek, J., C.S. Haase, and S.H. Stow.

   Rock cover (RC) wells surrounding the New Hydrofracture Facility were sampled in October 1983, January 1985, and May 1986. The eight wells are open to 30-m-long intervals in the Rogersville Shale and Rutledge Limestone that overlie the Pumpkin Valley Shale.

   The RC wells provide a means to sample indigenous formation water within these formations. Furthermore, because they overlie the host formation for injected waste-bearing grouts at the hydrofracture facility, the wells provide an opportunity to detect the bearing grouts at the hydrofracture facility, the wells provide an opportunity to detect the presence of radionuclides in the overlying formations. Samples were analyzed for major, minor, and trace elements. Gross alpha, beta, and gamma spectral scans, along with specific analyses for H-3, Co-60, Sr-90, Tc-99, and Cs-137, were obtained. The RC well waters are low-alkalinity, low-pH, Na-Ca-Mg-Cl brines. Total dissolved solid contents range between 150,000 and 200,000 ug/mL. Compositional variability between individual wells and between various samplings of each well suggests that the subsurface hydrological system at the hydrofracture facility is not static. Chemical and radionuclide data for the samples suggest the possibility that small amounts of waste-derived fluids have mixed with waters sampled in the RC wells. Whether the waste-derived fluid migrated upward from the Pumpkin Valley Shale or outward from the injection well casing cannot be determined with available data.

2. ORNL/RAP-6, 50 pp. (1987, April), Geochemistry of Formation Waters in the Lower Conasauga Group at the New Hydrofracture Facility: Preliminary Data from the Deep Monitoring (DM) Wells. Haase, C.S., J. Switek, and S.H. Stow.

   Deep monitoring (DM) wells surrounding the New Hydrofracture Facility were sampled in September 1984, January 1985, and January 1986. The seven DM wells are open to various intervals within the Rutledge Limestone, the Pumpkin Valley Shale, and the Rome Formation. These wells provide a means to sample groundwaters within these formations and an opportunity to detect the presence of radionuclides within those groundwaters. Samples were analyzed for major, minor, and trace elements. Gross alpha, beta, and gamma spectral scans were obtained along with specific analyses for H-3, Co-60, Sr-90, and Cs-137. Groundwaters sampled by the DM wells are low-alkalinity, low-pH, Na-Ca-Mg-Cl brines. Total dissolved solid values for most wells range between 150,000 and 200,000 ug/mL. Compositional variability between individual wells and between various samplings of each well suggests that the subsurface hydrological system at the hydrofracture facility is not static. Chemical and radionuclide data for the samples suggest that significant amounts of waste-derived fluids have mixed with groundwaters in the Pumpkin Valley Shale 1000 ft east and west, respectively, of the New Hydrofracture Facility site. Pumpkin Valley Shale groundwaters 1000 ft northwest of the hydrofracture site, however, do not contain appreciable amounts of radionuclides.

The data further indicate that significant amounts of waste-derived fluids also occur in groundwaters of the Rome Formation 1000 ft east and west of the hydrofracture site. Rutledge Formation groundwaters 1000 ft to the east and northwest of the site contain very low levels of radionuclides. Levels of radionuclides observed in DM wells open to the Rutledge Formation are similar to those noted in Rock Cover wells open to the Rutledge and Rogersville formations in the immediate vicinity of the New Hydrofracture Facility. Such data indicate that only small amounts of waste-derived fluids have mixed with groundwaters in the formation immediately overlying the Pumpkin Valley Shale.

3. ORNL/RAP-9, 31 pp. (1987, January), Remedial Action Plan for ORNL Hydrofracture Operations. Myrick, T.E. and S.H. Stow.

Hydrofracture, or shale fracturing, is a process developed at Oak Ridge National Laboratory (ORNL) for the permanent disposal of locally-generated liquid, low-level waste (LLW) solutions. In the hydrofracture process, hydraulic pressure was used to initiate the formation of a fracture between layers of shale, at depths between 700 and 1,000 ft. The LLW solution was then mixed with a blend of solids composed of cement and other additives, and the mixture injected under pressure into the fractured shale. As the injection progressed, the grout mix continued the shale fracturing, forming thin horizontal sheets several hundred feet across. The grout set after injection, fixing the wastes in the highly-impermeable shale.

Since the first experimental injections in 1959, this process has been utilized for the routine disposal of LLW, with over 7.5 Mgal of waste disposed of to date. Issuance of Underground Injection Control (UIC) Regulations by the Tennessee Department of Health and Environment (TDHE) and the Environmental Protection Agency (EPA) has resulted in reevaluation of the ORNL hydrofracture operations, in light of tighter standards for injection well construction specifications. Under these regulations, permitting and continued operations of the existing hydrofracture injection well will not be pursued by DOE. Instead, this remedial action plan has been prepared to outline the scope of corrective actions needed to place the inactive injection sites into a condition that assures adequate protection of the groundwater resources of the State of Tennessee, in accordance with UIC as well as Resource Conservation and Recovery Act of 1979 (RCRA) Regulations. The closure plan presented here provides a brief summary of the operational history of hydrofracture operations, an outline of the scope of the remedial action efforts in relation to other ORNL remedial actions and an overview of the program approach, details of the near-term schedule for plan implementation, and a reference list.

4. ORNL/RAP-10, 408 pp. (1987, March), Environmental Data Package for the ORNL Seepage Pits and Trenches Waste Area Grouping. Spalding, B. P.

The Oak Ridge National Laboratory Remedial Action Program has determined through its organizational studies that the seepage Pits and Trenches Waste Area Grouping (WAG) continues to release radioactivity to White Oak Creek. The area, therefore, requires application of the site stabilization and remedial action provisions under Section 3004(u) of the 1984 amendments to the Resource Conservation and Recovery Act of 1976. This recent section requires that any facility permit for handling or storing hazardous substances issued after November 8, 1984, include planned corrective actions for all continuing releases of hazardous waste or constituents from any disposal unit at the facility regardless of when the waste was placed at the disposal unit. Under this provision, a Remedial Investigation/Feasibility Study (RI/FS) forms the basis for determining the necessity for and/or extent of actions. This report assembles the known information on all waste management units within the seepage Pits and Trenches WAG as an initial step in the RI/FS process for this area. The seven ORNL seepage pits and trenches were used for the disposal of about 42 million gallons of radioactive liquid waste between 1951 and 1966.

At the time of transfer to these pits and trenches, a total of about 1.2 million curies of hard-beta activity were disposed although much of the short-lived isotopes, particularly the large amounts of Ru-106 and the trivalent rare earths, have decayed. However, there is a legacy of about 200,000 Ci of Sr-90 and 600,000 Ci of Cs-137 and a much smaller amount of U and transuranic isotopes which will remain a potential source of groundwater and surface water contamination for several hundred years. Past operational records, engineering designs, and characterization/performance investigations have been summarized. Appendices of reports, photographs, line drawings, and engineering drawings have been included. The planning and operational history have been presented in the context of the Laboratory's liquid waste disposal problems through the years. Concerns for both the long- and short-term radiological hazards posed by the operation of the pits and trenches led to their abandonment in 1966 when the hydrofracturing disposal technique became operational. The Pits and Trenches WAG also contains several other waste management units which need to be considered in evaluating the potential performance of the area. These include the contaminated equipment storage area (7841), the first experimental hydrofracture test site, two significant leak sites in the old liquid waste transfer line in the area, the surplus decontamination building (7819), and seven special waste disposal wells near seepage trench 5. The inventory of radioactivity in these other units is small by comparison to that in the seepage pits and trenches. Although there is considerable existing characterization information about these areas, many additional information needs were identified which will be required to plan their closure. Empirical leach rate data for the waste forms in each pit and trench will be required. Some improvement in the sites' groundwater and surface water monitoring system has been suggested including flow-proportional sampling and discharge monitoring in the one presently unmonitored drainage basin. In addition, the known active groundwater seeps in the area should be monitored for a two-year characterization period until their seasonal contributions to the areas' surface water discharges can be quantified. Other geologic, pedologic, and hydrologic characterizations of the area appear to be quite adequate for planning closure. However, the spatial distribution of radioactivity in and around each pit and trench needs to be determined with much more resolution than is available at present.

The use of an in situ radiation detector, fitted on a retrievable and hydraulically inserted lance, is proposed as a tool to achieve the detailed contamination mapping. Hydrologic and soil chemical speciation modeling needs are presented. such models will be required to predict radionuclide migration into the future so that the radiological impacts of these sites can be determined. The techniques for the stabilization and closure of each pit and trench will depend strongly on the magnitude of these predicted radiological doses when these sites are no longer under the institutional control of ORNL.

5. ORNL/RAP-13, 97 pp. (1987, March), Environmental Data Package for the Main Plant Area (WAG 1). Boegly, W.J., R.H. Ketelle, R.R. Lee, and H.C. Claiborne.

U.S. Department of Energy facilities are required to be in full compliance with all federal and state regulations. In response to these requirements, the Oak Ridge National Laboratory (ORNL) has established a Remedial Action Program to provide comprehensive management of areas where research, development, and waste management activities have resulted in residual contamination of facilities or the environment. In, 1986, the Environmental Protection Agency elected to enforce its regulatory requirements for remedial action through Sect. 3004(u) of the amended Resource Conservation and Recovery Act (RCRA) of 1984. As the first step in identifying compliance requirements under RCRA Sect. 3004(u) for ORNL, a list of all known active and inactive solid waste management units, contaminated facilities, and other potential sources of continuing releases to the environment was prepared. Included in this list were waste collection and storage tanks, solid waste storage areas, waste treatment units, impoundments, spill sites, pipeline leak sites, underground injection wells, and areas of known contamination in order to maintain a comprehensive inventory of all ORNL sites that might require some form of remedial action. The listing compiled for ORNL includes about 250 sites that might be considered for Sect. 3004(u) remedial action. Because of the complex hydrogeology of ORNL and the large number of sites involved, the ORNL sites have been grouped into 20 geographically contiguous and hydrographically defined Waste Area Groupings (WAGs). This report covers only the Main Plant Area (WAG 1) and the 99 Solid Waste Management Units (SWMUs) identified within its boundary. The purpose of this environmental data package is to provide background information on the geology, hydrology, soils, and geochemistry of the WAG 1 area, as well as information on releases and inventories of hazardous materials for individual sites (SWMUs) within WAG 1, that will be required for additional remedial action evaluations. Areas where additional site information will be required are identified.

6. ORNL/RAP-19, 115 pp. (1987, June), Environmental Data Package for ORNL Waste Area Grouping-5 (WAG-5), Solid Waste Storage Area-5 (SWSA-5). Shoun, R.R.

   The ORNL Waste Area Grouping-Five (WAG-5) consists of ten subgrouping which include not only the Solid Waste Storage Area-Five (SWSA-5) itself, but nearby low level waste (LLW) line leak sites, the Old Hydrofracture Facility (OHF) surface facilities, tanks, sludge basins, and the New Hydrofracture Site surface facilities. This report describes the site locations, the site history, known waste inventory and releases, the hydrology, geology, and ecology, and remedial actions taken in the past. Supporting bibliography, drawings, and pictures are included as considered appropriate. This document is not intended to be an exhaustive compilation of data, but to be a starting point for assimilation of information necessary for the decision-making processes mandated by the Resource Conservation and Recovery Act (RCRA).

10. ORNL/RAP/LTR-85/7, 5 pp. (1985, August 19), Status of Contamination of White Oak Creek Watershed: 1985 Progress Report, 19 August 1985. Cerling, T.E.

   Seventeen sites were chosen to study the active vs. passive nature of contamination in the White Oak Creek Watershed. Gravel fractions were sampled and studied for radionuclide content. Sites are subdivided into primary and secondary according to whether water samples were available. Sites are listed.

12. ORNL/RAP/LTR-86/8, 92 pp. (1986, January 31), Identification of Low-Level Waste Leak Sites at the Oak Ridge National Laboratory. Grimsby, H.J.

   Thirty-five sites were identified where leaks or spills occurred during the operation of ORNL's low-level liquid waste system. Excerpts from reports and summaries of interviews are included, where available, for each specific site. In general, there is a scarcity of detailed information pertaining to the exact composition, volume and location of the purported leaks, and details of cleanup efforts, if any, are equally vague. The thirty-five sites have been categorized into five groups based upon their geographical proximity. Three groups consisting of a total of 23 sites are located within the main complex of ORNL (Bethel Valley) with the remaining 12 sites lying in the Melton Valley region of ORNL. Estimates of the extent of contamination at most sites will require additional information. Isolated characterization and site performance monitoring will be difficult for those sites located within ORNL's main complex, and remedial actions will be difficult to employ given their location in a heavily congested area. Inclusion of many of the LLW line leak sites with other Remedial Action Program (RAP) sites should be considered; a listing of LLW line leak sites and nearby RAP sites is included.

13. ORNL/RAP/LTR-86/12 (1986, January 31), Action Plan for Site Performance Model. Lee, D.W.

    The action plan for the site performance model has been prepared to document the approach to be taken in developing a site performance model applicable to the Oak Ridge Reservation. The central objective of the site performance model is to develop a global model for the transport of contaminants in the White Oak Creek Watershed. The model will be used as a tool for decision making for the cleanup of remedial action sites within the watershed. The model will address the ultimate fate of contaminants in the groundwater system, the sediments of White Oak Creek and White Oak Lake, and the soils associated with the individual remedial action sites. The approach to performing this task is described in the form of a series of subtasks in this report.

14. ORNL/RAP/LTR-86/14 (1986, July 15), Inventory of ORNL Remedial Action Sites: 3 - Process Ponds. Taylor, F.G.

    The Process Pond sites, identified as remedial action sites of the Environmental Restoration and Facilities Upgrade Program (ERFU), have been visited and the activities concerning each site reviewed by personal interview with persons knowledgeable about the site. Additional information was abstracted from reports, publications, and engineering drawings. Results of each review are presented to provide information on the pond location and description, history, contaminants, extent of contamination, major references (reports, drawings, etc.), and identification of knowledgeable persons concerning the site.

15. ORNL/RAP/LTR-86/15, 1 p. (1986, January 22), Soil and Sediment Sampling of RCRA Ponds at ORNL. Francis, C.W. and J.T. Kitchings.

    Sediment sampling has been completed at all seven RCRA ponds, except the 3524 pond (SWMU 01.13). This pond recently received considerable radioactivity as a result of the excavation of the contaminated drainage lines from 3517 making sediment sampling at this time a radiological hazard. Sediment samples (or sludge samples) will be (or are in the process of being) extracted using the EP toxicity test to determine their toxicity characteristics under RCRA. An overall strategy for collection of soil samples from pond berms is currently being developed.

16. ORNL/RAP/LTR-86/16, 1 p. (1986, January 22), Environmental Characterization Plan for Groundwater Sampling of RCRA Ponds at ORNL. Francis, C.W. and J.T. Kitchings.

The objective of this subtask is the scheduling and coordination of groundwater sampling in the vicinity of ORNL active impoundments. The purpose is to insure that the groundwater samples are collected at each of these locations according to regulatory requirements. The plan addresses sample collection, sample analysis, and data integration and analysis. Dates for sampling, completion of chemical analyses, and reporting to DOE have previously been outlined in ORNL/RAP86-1.

18. ORNL/RAP/LTR-86/20, 23 pp. (1985, January 14), Stream Survey Information. Cerling, T.E.

This report represents a quarterly update which summarizes the work on contamination investigations in the White Oak Creek Drainage Basin and includes a synopsis of active contamination sites in the watershed. The cover letter included with the report summarizes the key findings, describes several improvements since 1978, and discusses "new" contamination sources at First Creek and in the eastern part of SWSA 6.

19. ORNL/RAP/LTR-86/23, 59 pp. (1986, July), Inventory of ORNL Remedial Action Sites: 4 - White Oak Creek Watershed. Edwards, N.T.

This report contains an abbreviated account of the history of the White Oak Creek Watershed after construction of the White Oak Dam and of laboratory activities and waste disposal operations which have contributed radionuclides and other potentially hazardous chemicals to both aquatic and terrestrial areas within the Watershed. It also summarizes radionuclide monitoring data in White Oak Lake, White Oak Creek, and Melton Branch Creek. Summarized data from much of radionuclide research conducted on the Watershed are presented, including concentration data in groundwater, lake sediments, gravels along stream beds, aquatic biota, and terrestrial biota and soil. These concentration data are used to identify key sources of contamination and for locating areas and biota some distance from these sources which contain relatively large amounts of contaminants. The report also identifies some recent remedial action activities in the area of waste disposal aimed at reducing releases of pollutants to the Watershed environment. New research activities aimed at better understanding the fate and effects of pollutants of special concern in the White Oak Creek Watershed, and recommendations for further research are discussed. Key reports which address levels of non-radiochemical contaminants in the Watershed are referenced.

23. ORNL/RAP/LTR-86/32, 12 pp. (1986, March 31), Placement Planning for Bethel Valley Water Quality Monitoring Wells. Huff, D.D. and R.H. Ketelle.

This letter report meets milestone 3.7.a of the Remedial Action Program and represets a status report on work completed through March, 1986. There are three components to placement planning for water quality (QW) wells that have been addressed: identification of waste management areas (WMAs), which include collections of sites of concern; integration of the schedule for installation and data collection for piezometer wells into minimum requirements for developing technical specifications for QW wells; and ordering of WMAs into prioritized groups for scheduling of technical specifications' development and installation. Because there have been recent changes in overall strategy, the planning has been modified, and this letter report should be viewed as a current status report. The schedule put forward in this plan extends over both Bethel and Melton Valleys and provides a more detailed basis for planning than previously available. These plans should be considered for subcontracting needs and schedules in support of well installation, for determining compliance sampling and analytical chemistry requirements, and for potential timing conflict with remedial action/stabilization schedules.

24. ORNL/RAP/LTR-86/35, 79 pp. (1986, July 1), Inventory of ORNL Remedial Action Sites: 1 - Solid Waste Storage Areas. Grizzard, T.

    Shallow land burial has been the method for disposal of solid low-level [both low activity (less than or200 mR/h) and high activity (greater than 200 mR/h)] radioactively contaminated waste at Oak Ridge National Laboratory (ORNL) since the beginning of operations in 1943. Most of the waste disposed of at ORNL has come from various facilities within ORNL, but additional solid radioactively contaminated waste has been received from other sources (mainly DOE contractors). Six solid waste storage areas (SWSAs) have been used since land disposal began at ORNL in 1943. The SWSAs are numbered consecutively in the order in which they were opened and used. This report discusses each of the six SWSAs used at ORNL as well as two other sites, the White Wing Road Storage Area and the Closed Contractor Landfill. Nuclide activity levels and volumes of waste disposed/stored on the Oak Ridge Reservations are presented, where available.

25. ORNL/RAP/LTR-86/39, 44 pp. (1986, April 28), A Ranking of Contaminant Sources in the White Oak Creek Drainage. Huff, D.D.

    The purpose of this report is to present a ranking of contaminant sources in the White Oak Creek drainage. The basis of the ranking is a combination of results from a survey of the presence of water-borne contaminants in streams in the White Oak Creek drainage, obtained by Dr. T. Cerling, and data provided by K. Daniels, L. Melroy, and E. Davis from flow measurements in the basin. Presence of contaminants was assayed using streambed materials that were either suspended in flow (active sources) or collected from the channel bottom (historical sources) during the July through August 1985 time period, then analyzed to determine the change in contaminant content. Flow data were compiled into volume totals for the July 1 - August 31 period, then converted to an average flow rate for that interval. The product of flow rate in cubic feet per second (cfs) and total accumulated contaminant in Bequerels per kilogram for nuclides or parts per million extractable metal for zinc was used as a relative indicator of flux. Since the level of detail for flow data was somewhat limited, the ranking has been confined to the level of waste management areas (WMAs).

26. ORNL/RAP/LTR-86/40, 39 pp. (1986, May 20), Report on Groundwater Suppression Using a French Drain. Davis, E.C. and D.S. Marshall.

Engineered modifications or engineered barriers have been suggested as a means of improving the performance of low-level radioactive waste disposal sites located in the humid eastern United States. One such engineered barrier, a passive French drain, was constructed at the Oak Ridge National Laboratory to determine its ability to hydrologically isolate a group of 49 waste trenches located in a currently operating disposal site. The 252 m drain was constructed in two sections (a north and east leg) with the primary design goal of lowering the area water table that was observed to intersect the trench bottoms during wet months of the year. By lowering the water table and dampening out seasonal fluctuations, it was anticipated that the seasonally inundated trenches would begin to drain. Results of over two years of environmental monitoring indicate that seven of the trenches have been completely dewatered as a result of drain construction and the water table over approximately 50% of the site has been lowered to a point that it no longer intersects the trench bottoms. Discharge from the longer east leg of the drain has been continuous with an estimated volume of 4,307 and 2,634 cubic meters of water being removed from the aquifer in 1984 and 1985, respectively. The drawdown caused by the drain extends 50 to 60 m horizontally from the drain centerline and has been found to cause an approximate 4 m vertical drop in water level in the northeast corner of the site where the two legs of the drain intersect. A simple analytical solution to a generalized drainage problem is presented and applied to the 49-trench area with results indicating that the predicted extent of the drawdown curve (54 m) matches what was observed in the field. A graphical solution to the generalized groundwater flow in the vicinity of a French drain is developed and can be used to help design additional drainage projects in different types of geologic materials.

27. ORNL/RAP/LTR-86/41, 25 pp. (1986, June 17), Sampling and Analysis of SWSA-6 Trench Leachates and Groundwaters: Methods and Initial Observations. Solomon, D.K., J. Switek, H.A. Friedman, and A.D. Kelmers.

Three trench leachate samples and one groundwater sample have been collected as part of the characterization of Solid Waste Storage Area 6 (SWSA-6). A total of 14 samples are planned; however, unusually low precipitation has resulted in many dry trenches which has caused delays in sampling. Eleven of the required monitoring wells are in place and two more are scheduled to be completed by mid-July. All samples collected to date contain appreciable quantities of beta-emitting radionuclides (primarily H-3 and Sr-90). A number of EPA priority pollutant organic compounds were detected, including naphthalene and toluene, which are present at appreciable concentrations. Two additional groundwater samples will be collected by the end of July, and the remaining trench leachate samples will be collected as soon as sufficient water exists within the trenches. All samples exceeded the EPA Interim Primary Drinking Water Standards for alpha- and beta-emitting radionuclides. Two samples contained concentrations of organics (chloroform, methylene chloride, and naphthalene) in excess of the State of Tennessee Guidelines for Superfund Sites.

28. ORNL/RAP/LTR-86/42, 5 pp. (1986, June 27), 3019/3074 Wet Weather Dye Tracer Study. Melroy, L.A.

The purpose of this study was to examine possible groundwater contamination migration pathways from the Low-Level-Waste (LLW) transfer line leak between buildings 3019 and 3074 during high water-table (winter) conditions. Methods, hydrologic conditions, and results are discussed. It is concluded that two major flow components exist. Both components are controlled by rock fabrics.

29. ORNL/RAP/LTR-86/47, 5 pp. (1986, June 30), 1985 White Oak Creek and Tributaries Streambed Contaminant Survey. Cerling, T.E.

The objectives of the streambed contaminant survey reported here were to provide a basis for ranking corrective measures projects and to facilitate identification of sites where further studies are needed to characterize contaminant migration in the White Oak creek watershed. This report includes a summary of the active and inactive sources of radionuclide contamination in 1985, recommendations on waste area groupings (WAG) that will require cleanup under RCRA, and a ranking for WAG's that is based on the magnitude of releases.

30. ORNL/RAP/LTR-86/48 (1986, June 30), ORNL Contaminant Scoping Survey. Doyle, T.W. and F.G. Taylor.

As part of the ORNL Remedial Action Program, a preliminary contaminant scoping survey was conducted for groundwater of the several solid waste storage areas, chemical waste pits, seeps, and sediments of White Oak Lake. A total of 31 wells, 4 seeps, and 3 sediment samples were collected. Analyses included metals, total toxic organics, and radionuclides. Results from these samples will be used to characterize and assess ORNL remedial action needs and priorities.

31. ORNL/RAP/LTR-86/50, 182 pp. (1986, June), Biological Monitoring Plan and Abatement Program for White Oak Creek Watershed and the Clinch River. Loar, J.M., S.M. Adams, B.G. Blaylock, H.L. Boston,

M.A. Huston, B.L. Kimmel, C.R. Olsen, J.G. Smith, G.R. Southworth, A.J. Stewart, and B.T. Walton.

On April 1, 1986, a National Pollutant Discharge Elimination System (NPDES) permit was issued for the Oak Ridge National Laboratory (ORNL) (EPA, 1986). As specified in Part III: Special Conditions (Item H) of the permit, a plan for biological monitoring of the Clinch River, White Oak Creek, Northwest Tributary of White Oak Creek, Melton Branch, Fifth Creek, and First Creek shall be submitted for approval to the U.S. Environmental Protection Agency (EPA) and the Tennessee Department of Health and Environment (TDHE) within 90 days of the effective date of the permit. The plan, which is referred to in Part III (H) of the permit as the Biological Monitoring Plan and Abatement Program (BMPAP), describes characterization/monitoring studies to be conducted for the duration of the permit (5 yr). The proposed BMPAP outlined in this document is based on preliminary discussions held on December 9, 1985, between staff of Martin Marietta Energy Systems, Inc. (ORNL and Central Management), the U.S. Department of Energy (DOE), the EPA, and the TDHE. The proposed BMPAP was developed to meet the following objectives: (1) to provide sufficient data to demonstrate that the effluent limitations established for ORNL protect and maintain the classified uses of White Oak Creek and Melton Branch as identified in the State of Tennessee Water Quality Management Plan for the Clinch River Basin; (2) to provide ecological characterization s of White Oak Creek and tributaries and of White Oak Lake that can be used to document ecological impacts of past and current operations, identify contaminant sources that adversely affect stream biota, and provide baseline data that can be used to determine the effectiveness of remedial actions; and (3) to document the effects on stream biota resulting from implementation of a Water Pollution Control Program (WPCP) at ORNL.

32. ORNL/RAP/LTR-86/59, 3 pp. (1986, September 2), Well Inventory for ORNL Hydrofracture Sites. Switek, J. and S.H. Stow.

Included is a well inventory for the ORNL hydrofracture sites. This report represents the completion of the first phase of the plugging and abandonment activity for the hydrofracture closure. Included are: well name, completion date, depth, casing data, drilling method, radionuclide data, water chemistry, and geological/geophysical/core availability. A complete list of references for data is given.

33. ORNL/RAP/LTR-86/61, 79 pp. (1986, September 3), Data Package for Water Balance Studies in ORNL SWSA-6. Davis, E.C., D.K. Solomon, and P.M. Craig.

The purpose of this report is to identify the types of data being collected in this characterization effort and assemble information collected through July 1986. The characterization work plan for FY 1987 includes updating these data sets and constructing a detailed water balance for SWSA-6. Included are data sets for:

precipitation, stream flow, water table, and soil moisture.

34. ORNL/RAP/LTR-86/62, 42 pp. (1986, September 30), Discharge Forecast for the White Oak Creek Watershed: FY 86 Annual Progress report. Sale, M.J., D.D. Huff, S.F. Railsback, and D.M. Borders.

    This letter report presents the end-of-the-year status of data acquisition and model development for surface runoff forecasting and prediction of downstream dispersion-transport of pollutions released from White Oak Dam (WOD). The runoff forecasting model has been set up for the entire WOC basin, but has only been calibrated for a small representative watershed. A dispersion model developed by Tennessee Valley Authority has been modified to predict downstream concentrations of SR-90 released at WOD. This model is operational but requires further calibration and testing.

35. ORNL/RAP/LTR-86/64, 12 pp. (1986, September 15), Sampling and Analysis of SWSA-6 Trench Leachates and Groundwaters: II - Additional Data Obtained During FY 1986. Solomon, D.K., J. Switek, H.A. Friedman, and A.D. Kelmers.

    Due to the severe drought during the summer of 1986, no trench leachate or groundwater from nearby wells could be sampled. During this report period, one sample was taken from the standing water table beneath SWSA-6 (well E-117) and thoroughly analyzed. The sample appeared to be typical SWSA-6 groundwater. The alpha, beta, and gamma radioactivity levels were low. Only two contaminants, 1,1-dichloroethane, at 10 ug/L, and mercury, at 0.0007 mg/L, were detected.

36. ORNL/RAP/LTR-86/67, 12 pp. (1986, September 26), Trench-Water Dynamics in SWSA-6: Methods and Preliminary Observations. Solomon, D.K. and J. Switek.

    This report describes the procedures being used to estimate the monthly groundwater discharge from trenches along with preliminary results for seven trenches in SWSA-6. This is done in order to estimate the rate at which contaminants are released from the waste. It is estimated that about 90% of the trenches in SWSA-6 are in contact with groundwater. Computed discharges for 7 trenches ranged from 0 to 463 cubic feet per month. Precipitation could account for 60% of the total input and thus lateral subsurface flow is considered to be significant.

37. ORNL/RAP/LTR-86/68, 8 pp. (1986, September 25), Contaminant Transport Modeling of SWSA-6: First Progress Report. Craig, P.M. and E.C. Davis.

    The purpose of this contract is to perform a groundwater contaminant transport analysis, which is required to determine and quantify radionuclide pathways. Results will be used to identify the source (if any) in need of remedial action and to obtain estimates of offsite contaminant transport via surface waters, for use in exposure analysis. Progress has been made in the modeling of SWSA-6. An overall plan has been outlined for flow model completion. A brief description of the mass transport modeling analysis is given.

38. ORNL/RAP/LTR-86/71, 48 pp. (1986, September 24), Preliminary Assessment of the Radiological Impact for the Individual Waste Management Areas at the Oak Ridge National Laboratory: Status Report. Sears, M.B.

A study was made (1) to estimate the radiological impact (i.e. the doses) for individual waste management areas at the Oak Ridge National Laboratory and (2) to rank the areas for remedial action based on the off-site doses which result from discharges to surface streams. Some data was found for Sr-90, but quantitative source term data for individual sites was not found for H-3, Cs-137, or Co-60. A qualitative assessment was made and areas were ranked for remedial investigation based on the available information.

39. ORNL/RAP/LTR-86/72, 36 pp. (1987, February 26), Simulation of Water Balances in Trenches Using a Finite Element Moisture Movement Model. Yeh, G.T.

The first objective of this task is to select a computer program (FEMWATER) that can be used to simulate the water movement through trenches and the surrounding media. The second objective is to apply the modified program to the "49 trench area", particularly Trench 150. Results show that the modified FEMWATER program is feasible; a simulation of the "49 trench area" was performed and the predicted water level was nearly identical to the observed value. Conclusions: (1) "bathtubbing" occurs only in the down-slope trenches; (2) about 15% of the water entering the trenches comes from the surrounding media; and (3) water from saturated soils around the trenches continues to enter the lower trenches even after the rainfall stops.

40. ORNL/RAP/LTR-86/75, 31 pp. (1986), 1986 Groundwater System Characterization - ORNL. Ketelle, R.H., M.A. Faulkner, D.D. Huff, J.D. Tuggle, and L.D. Voorhees.

The material presented here focuses on the first stages of the task of groundwater system characterization: installation, data collection, and initial results associated with exploratory piezometer wells. Where appropriate, new well installations have been integrated with the older, existing well network. Progress in FY 1986 has been aimed at establishing the database needed for siting of the water-quality monitoring wells to be installed in FY 1987.

41. ORNL/RAP/LTR-86/76, 8 pp. (1986, October 1), Groundwater Sampling Around RCRA Impoundments: First Year Results. Montford, M.A., K.L. Daniels, and J.T. Kitchings.

The first year of groundwater sampling was completed at ORNL around impoundments 3524, 7900, and 3539-40 under the interim status provisions for RCRA facilities as required by the Tennessee Department of Health and Environment. Eighteen wells around these areas were sampled for 33 parameters quarterly. Results were compared to EPA Interim Primary Drinking Water Standards. Several wells exceeded the standard. Analyses included tests for Cl, Fe, Fecal coliform, gross alpha, gross beta, Mn, Na, NO3, pH, Ra, Specific conductance, SO4, temperature, total organic carbon, and total organic halides. Results of these tests are given.

42. ORNL/RAP/LTR-86/81, 10 pp. (1986, September), Status of ORNL Water Quality Monitoring Well Program. Huff, D.D., R.H. Ketelle, and S.H. Stow.

This report discusses the water quality monitoring wells component of the Environmental Restoration and Facilities Upgrade Program (ERFU). The installation of water quality (WQ) monitoring wells at ORNL is based on the concept that well placement must meet regulatory needs and be determined from a combination of site-specific groundwater investigations and records from previous waste disposal operations. Because each well represents a substantial commitment in time, effort, and funding, the number of wells should be kept to a minimum. Toward that goal, piezometer wells have been installed to allow determination of aquifer characteristics such as flow directions and rates. The WQ well installations thus are staged to allow evaluation of piezometer well results prior to siting decisions. In addition, the planned sequence of WQ monitoring well installations recognizes the following factors: 1) nature and inventory of contaminants at a given site; 2) near-term release potential; 3) position relative to other potential upgradient resources; 4) regulatory considerations; and 5) costs and funding availability (Trabalka and Myrick, ORNL/TM-10244, 1986). Taken in combination, these considerations have resulted in the WAG definitions and planned installation sequences presented in this report. Locations of well sites are currently planned for WAG perimeters to conform with EPA's draft National RCRA Corrective Action Strategy and will be determined according to schedules presented in this report. The material presented here updates an earlier report, ORNL/RAP86-32. It is clear that the plans contained in this report will continue to be subject to change as new information becomes available. Thus, future updates are expected.

43. ORNL/RAP/LTR-86/84, 11 pp. (1986, September 29), Location of Water Table with Respect to Underground Facilities at Building 3505. Staub, W.P.

The objectives of this study are to determine whether underground facilities at Building 3505 extend below the water table and whether there is hydraulic communication between these facilities and adjacent groundwater. Several components of Building 3505 have the potential to collect water because they are below ground level (802 feet). Some of these structures (the canal and its sump and the dissolver pit, respectively) were designed to hold or collect water while others inadvertently collect water under upset conditions (open space around columns in Cells B, C, D, and E). The data presented here show that the canal sump is below the local shallow water table but is hydraulically isolated from both shallow groundwater in Piezometer well 578 and the deep groundwater in the sampling well. This condition will continue to exist so long as the concrete containment structure around the canal remains intact.

The bases of the dissolver pit and the column in Cell E are presently above the water table but that condition could change during a succession of abnormally wet years.

44. ORNL/RAP/LTR-86/85, 5 pp. (1986, September 30), Corehole WOL-1, Progress Report on Drilling Activities. Dreier, R.B.

As part of the SWSA-6 geologic characterization, a corehole is being drilled south of SWSA-6 on the southern side of White Oak Lake. Initially, the well was designed to extend only through the units that crop out in SWSA-6 (Nolichucky and Maryville members of the Conasauga Group), and would be used for SWSA-6 and White Oak Lake Floodplain investigations. Because of the boreholes' location, 2500 ft. along strike from the New Hydrofracture Facility, it was decided to deepen the well to core through the entire Pumpkin Valley Shale. Ultimately the well will be used to monitor groundwater in the Pumpkin Valley Shale. Core retrieved from this borehole will be used on of the Copper Creek Thrust Sheet. In order to fully characterize the fractures, oriented core was retrieved from as much of the upper section (Nolichucky and Maryville) as possible. In addition to core, geophysical logs will be obtained from the borehole. Results from this study will complement ongoing geologic investigations in Melton Valley as well as provide valuable site-specific information. Drilling began on 8-8-86 and to date has penetrated the Rutledge Limestone/Pumpkin Valley Shale contact at 1125 ft.

45. ORNL/RAP/LTR-86/87, 13 pp. (1986, September 30), Hydrostatic Head Monitoring Stations: Summary of Well Construction of GPP 84 (Pits and Trenches) and GPP 85 (SWSA-6) Well Clusters. Dreier, R.B.

The immediate purpose of the Hydrostatic Head Monitoring Stations (HHMS) is to characterize water table levels in waste management areas in Melton and Bethel Valleys. This will provide information on the distribution of hydrostatic head for different flow systems that have potential of transporting radionuclides, and will supplement geologic characterization studies in Melton and Bethel Valleys. Data from the monitoring stations will refine two and three dimensional groundwater simulation models by incorporating hydrostatic head distribution data, as well as stratigraphic, petrographic, and structural geologic data obtained from these wells. In addition, where feasible, groundwater well be sampled in individual wells. This information will be incorporated into groundwater simulation models and will help in the design and construction of a permanent groundwater monitoring system. To date, construction of the HHMS has been divided into several GPPs for fiscal year 1984, 1985, 1987, and 1988. The stations for each year are loosely grouped with respect to the 84 GPP (Pits and Trenches Area) and 85 GPP (SWSA-6) HHMS wells.

46. ORNL/RAP/LTR-86/95, 41 pp. (1987, June 30), Chemical and Radionuclide Data from the DM and Associated Wells at the New Hydrofracture Facility, Fall 1986. Haase, C.S., J. Switek, S.H. Stow, H.L. King, and P.H. Pollard.

    The purpose of this report is to present analytical data for groundwater samples collected in Fall 1986 from the seven DM wells at the NHF and from four core holes at the second hydrofracture site. Analytical data are presented for radionuclides as well as for major, minor, and trace non-radioactive constituents. This report also contains details of the sampling procedure and some preliminary interpretations of the data. A report that contains a more complete interpretation of the data will be issued in the future.

47. ORNL/RAP/LTR-86/97, 77 pp. (1986, December 5), 1986 Piezometer Well Installation at ORNL. Hyde, L.D.

    The purpose of this report is to document activities associated with the installation of piezometer wells at Oak Ridge National Laboratory (ORNL). This work involved the development of well installation specifications, material procurement, contractor selection and training, well locations definition, drilling methods and procedure development, drill cuttings control and disposal, health physics (HP) and industrial hygiene coverage, and documentation of drilling and well installation activities. This report describes the work performed and the procedures which were developed to ensure that installation of the wells could be safely accomplished with adequate protection of the workers and the environment. Well installation activities through September 30, 1986 are covered in this document.

48. ORNL/RAP/LTR-86/98, 581 pp. (1987, March 23), 1986 Piezometer Well Drilling Logs and Well Completion Detail Drawings. Hyde, L.D.

    Beginning in 1986, a Piezometer Well Installation Project was initiated as part of the Environmental Restoration and Facilities Upgrade Program. The purpose and scope of this project are described in detail in ORNL/RAP/LTR-86/97. This report documents the individual drilling logs and well completion detail drawings for each piezometer well. The well drilling daily reports for 1986 are also provided. These data were prepared by MCI Consulting Engineers, Inc., under contract to Martin Marietta Energy Systems, Inc.

49. ORNL/RAP/LTR-86/100, 14 pp. (1969, January 7), Investigation of Release of Approximately Two Curies of Sr-90 to Melton Creek from Exploratory Well S-220. Jordan, W.H., T.A. Arehart, J.H. Gillette, and H.O. Weeren.

On October 25, 1968, a committee was convened at the request of Alvin M. Weinberg to investigate a release of radioactivity to Melton Branch following the drilling of an exploratory well (S-220) through the several grout sheets formed around the hydraulic fracturing disposal well. Committee members were W.H. Jordan, Chairman, J.H. Gillette, H.O. Weeren, and T.A. Arehart. During the investigation D.M. Davis and C.R. Guinn of the Applied Health Physics and Safety Section and E.G. Struxness, W.C. McClain, and W. de Laguna of the Health Physics Waste Disposal Section discussed with the investigators the various factors leading to the release, the stream contamination that resulted, and the effectiveness of hydrofracturing as a method for disposal of intermediate-level waste. The operators provided descriptive material which, along with items brought out in the investigation, resulted in this resume.

50. ORNL/RAP/LTR-86/101, 10 pp. (1986, December 16), Plan for Characterization of Water Flow in Pipe Trenches in the Main Plant Area. Ashwood, T.L.

This report represents the plan for a two year study to characterize flow in the network pipe trenches underlying the Main Plant Area of Oak Ridge National Laboratory (ORNL). This is a preliminary plan and is intended to be updated as more information becomes available. Ground water monitoring at ORNL is accomplished through an extensive array of piezometers and monitoring wells installed in the water table aquifer. However, there is evidence that, in at least some areas, a significant component of the near-surface ground water flow occurs in the backfilled trenches surrounding subsurface pipelines (Ashwood et al., 1986). Eventually, such pipe trench flow probably follows one of four paths to White Oak Creek: (1) storm sewer lines; (2) sanitary sewer lines to the sanitary sewage treatment plant; (3) a combination of routes to the 3524 Equilization Basin and the 3544 Process Waste Treatment Plant; or (4) into the water table aquifer.

At least the first three of these pathways may completely bypass the existing system of ground water monitoring wells. Flow in trenches around process waste lines and low-level liquid waste lines is of particular interest since leaks in these lines may provide a source of contamination. The objective of this study is to characterize the flow in the trenches surrounding process waste lines (PWL) and low-level liquid waste (LLW) lines in the Main Plant Area such that we are able to: (1) evaluate the contribution of this flow to the overall contaminant input to White Oak Creek; (2) evaluate proposed remedial actions for contaminated ground water and soil; and (3) contribute to the solution of specific ground water problems.

51. ORNL/RAP/LTR-87/1, 5 pp. (1987, January 23), Hydrostatic Head Measuring Stations - Well Siting Plan - FY 86 GPP. Dreier, R.B.

The objective of this letter report is to provide the site plan for the FY86 General Plant Project (GPP) Hydrostatic Head Measuring Stations (HMSS) assigned to the vicinity of Oak Ridge National Laboratory (ORNL) Solid Waste Storage Area (SWSA) 4. Although the FY86 GPP was for design of wells only, and the construction is funded with an FY87 GPP, the project is referred to as the HHMS FY86 GPP in this report. Because of recently defined characterization needs for the ORNL hydrofracture facility and remaining needs near ORNL and SWSA 6, some of the HHMS sites are located away from SWSduct of the well siting plan is the HHMS FY86 GPP location map.

52. ORNL/RAP/LTR-87/4 (1987, January), Bibliographic Database and Other Information Resources Developed for the ORNL Remedial Action Program. Owen, P.T. and L.D. Voorhees.

This report documents the planning and implementation of an online annotated bibliographic database and reference collection of documents pertinent to the Oak Ridge National Laboratory (ORNL) Remedial Action (RA) Program. The Information Research and Analysis (IR&A) section of the Biology Division will develop and manage these resources for the RA Program. IR&A will provide comprehensive technical information support to the RA Program and its subcontractors.

53. ORNL/RAP/LTR-87/5, 9 pp. (1987, January 31), Discharge Forecast Model Project Quarterly Report - 1 October 1986 to 31 December 1986. Sale, M.J.

The Discharge forecast Modeling Project includes activities under Program Strategy Development for the Remedial Action Program RAP) at Oak Ridge National Laboratory (ORNL). The overall objective of the project is to develop computer-based simulation models that are capable of predicting surface water runoff and associated contaminant concentrations within the White Oak Creek (WOC) watershed and downstream of White Oak Dam (WOD) into the Clinch River and Watts Bar Reservoir. This letter report is the first of a series of quarterly reports intended to satisfy RAP milestones.

54. ORNL/RAP/LTR-87/10, 47 pp. (1987, March 17), Water Quality Monitoring Well Installation at ORNL. Hyde, L.D.

The Resources Conservation and Recovery Act (RCRA) 40 CFR Sect. 3004(u) requires that an investigation be performed for all sites previously associated with waste management operations to determine if these sites are a source of continuing release of hazardous wastes. ORNL's approach to compliance with these regulations requires that groundwater quality monitoring wells be installed around the perimeter of Waste Area Groups (WAG) to assist in the evaluation of whether or not a continuing release exists for the WAG. This report provides information on the groundwater quality monitoring (GQM) Well Installation Program at ORNL. The program is operated under the direction of the Remedial Action Implementation Group of the Waste Management Section of ORNL Operations Division.

55. ORNL/RAP/LTR-87/11, 37 pp. (1987, March 31), Cokriging Model for Estimation of Water Table Elevation: Model Description. Hoeksema, R.J. and R.B. Clapp.

The location of the water table is critical to the calculation of ground water flow patterns and, in some cases, to the interpretation of geochemical data. In hilly terrain, estimating the contours of the water table from observations at monitoring wells is problematic because the data set always will be sparse. To briefly illustrate this problem, suppose that water levels are available from two wells located on ridges separated by a swale or depression. Simple linear interpolation could imply that the water surface spans the swale, implying a lake between the ridges which, in fact, does not exist. Because the water table elevation is often a subdued replica of the ground water surface elevation, it is desirable to have analytic tools that can use this observed relationship in order to predict the needed elevations of the water table. This report describes innovative work to develop this analytic capability and provides an update on the data collection activities to support the model development. The computer model will be implemented on data gathered at the Pits and Trenches Area in Melton Valley in early April.

56. ORNL/RAP/LTR-87/13, 263 pp. (1987, March 18), FY 1987 Piezometer Well Installation at ORNL. Mortimore, J.A.

The purpose of this report is to provide continuing documentation of the activities associated with the installation of piezometer wells at ORNL. The purpose and scope of the program are described in detail in ORNL/RAP/LTR-86/97. This report covers the progress of the piezometer program in the first two quarters of FY 1987 and any changes since the 1986 report.

57. ORNL/RAP/LTR-87/14, 5 pp. (1987, March 18), FY 1987 Hydrostatic Head Measuring Stations Well Installation. Mortimore, J.A.

The purpose of this report is to describe the status of Hydrostatic Head Measuring Stations (HHMS) installation. Six of well clusters and one partial cluster currently exist in the Pits and Trenches area and in SWSA 6. These stations were installed in FY 1986 under GPP construction. The only scheduled GPP remaining for the installation of HHMS is the FY 1986-1987, "HHMS - SWSA 4". This project initially will consist of three full clusters and two partial clusters. Plans for possible additional clusters will be decided at a later date. The project is currently in a phase of document preparation and coordination of plant and contractual services necessary to begin construction. Construction is expected to begin early in the third quarter of FY 1987. The primary purpose of HHMS wells is to characterize the regional groundwater flow systems for specific areas at ORNL.

58. ORNL/RAP/LTR-87/20, 14 pp. (1987, April 22), Discharge Forecast Modeling Project Quarterly Report January 1, 1987 to March 31, 1987. Borders, D.M.

The Discharge Forecast Modeling task is included in activities under Program Strategy Development for the Remedial Action Program (RAP) at Oak Ridge National Laboratory (ORNL). The objective of the task is to implement a computer-based simulation model to forecast surface-water runoff, associated contaminant concentrations within the White Oak Creek (WOC) watershed, and subsequent releases from White Oak Dam (WOD). This letter report is one in a series of quarterly progress reports.

59. ORNL/RAP/LTR-87/21, 81 pp. (1987, June 25), Investigations for Contamination in Cores of Bedrock Taken Under Two Waste Impoundments at Oak Ridge National Laboratory. Francis, C.W. and L.K. Hyder.

Cores of bedrock and soil taken below two impoundments formerly used at Oak Ridge National Laboratory to treat and dispose of liquid low-level radioactive wastes were examined for contamination. Two cores, ranging in length from 80 to 100 ft and in depth from 75 to 90 ft, were drilled at angles under each impoundment. Analyses of groundwater at these impoundments had shown the groundwater downgradient of the impoundments to be contaminated with Sr-90 (a beta-emitting radionuclide). As a preliminary indicator of potential contamination in the bedrock, particulate matter sloughed from the cores and then sieved to less than 1 mm diam were assayed for gross alpha and gross beta activity. Selected samples were analyzed for Sr-90 and gamma-emitting radionuclides. Mercury was also assayed in bedrock samples taken below an impoundment known to contain sediment whose extractable concentration of mercury by the Resource Conservation and Recovery Act (RCRA) extraction Procedure (EP) waste leach test classified the sediment as a toxic hazardous waste. Gross alpha and gross beta measurements indicated that the bedrock below these impoundments is not contaminated with radioactivity. However, Sr-90 and Cs-137 analyses revealed detectable concentrations in bedrock samples below the impoundment at the Old Hydrofracture Facility (approximately 50 Bq/kg, small as compared with the 1600 Bq/kg of gross beta activity measured in uncontaminated bedrock adjacent the area). Soil overlying the bedrock and adjacent to the downgradient side of both impoundments contained detectable levels of radioactivity. At the Old Hydrofracture Facility, soil contained as much as 1.2 x 10 (E+5), 3200, and 200 Bq/kg of gross beta, Cs-137, and Co-60, respectively. The high concentrations of radionuclides observed in the bedrock samples indicate that the major route of contamination from the impoundments is seepage of pond water and leachate water from the impoundment sediment into groundwater that moves downgradient along the highly fractured interface between the bedrock and the overlying soil.

60. ORNL/LTR-87/22, 7 pp. (1987, May 29), Radiological Results of Sediment and Water Samples Taken at the Base of the Building 3019 Stack. Williams, J.K. and C. Clark.

A radiological sampling survey was conducted on November 11, 1986, by the Environmental Assessments group of the Health and Safety Research Division (HASRD), Oak Ridge National Laboratory (ORNL), and personnel of the ORNL Operations Division at the request of the Maintenance, Surveillance and Corrective Actions (MS & CA) Program of ORNL. The purpose of the survey was to determine [via sediment (S1 and S2) and surface water runoff (W1) samples] the nature and extent of radiological contamination in a storm sewer catch basin located at the base of the Building 3019 stack. The survey site, referred to as the "3019 hot bank," is located south of Building 3020 and north of Building 3019 at ORNL. Building 3020 houses the 3019 stack. Potential contributing sources of radiological contamination at the base of the 3019 stack and bank area are, reportedly, stack emissions and low-level radioactive waste (LLW) leak sites, identified as solid waste management units (SWMUs) 1.5a, b, and c. Results of this survey show significant radiological contamination in the storm sewer catch basin. The S1 sediment sample contained the highest radionuclide concentrations and gross alpha and beta activity. However, it is significant that the W1 surface water sample collected from the storm sewer catch basin southwest of the chimney-vent station contained 200 pCi/L of Sr-90 and a gross beta activity of 260 pCi/L. For comparison, Sr-90 concentrations in the W1 water sample (200 pCi/L) exceed the Environmental ProtecA) National Primary Drinking Water Regulations (NPDWR) standard of 8 pCi/L by a factor of 25. Additionally, the S2 sediment sample contained 51 pCi/g of Sr-90 and a gross beta activity of 190 pCi/g.

61. ORNL/RAP/LTR-87/27, 20 pp. (1987, May 29), Core Drilling at White Oak Dam. Selfridge, R.J. and C.B. Sherwood.

The purpose of this report is to document the results of drilling and testing a 900-ft core hold at White Oak Dam (WOD). The core was drilled to characterize the subsurface hydrogeology in the WOD vicinity and, in particular, to detect and evaluate permeable zones which may permit the flow of groundwater and contaminants under or around the dam. The information will also be used in selecting depths for clusters of water quality monitoring wells to be drilled at the dam. This work represents one of the hydrogeologic characterization needs outlined by Sherwood and Loar (1986), who summarized the hydrogeologic and ecologic characteristics of the White Oak Creek (WOC) flow system, and the nature and quality of contaminants released to and from the system.

62. ORNL/RAP/LTR-87/33, 14 pp. (1987, July 31), Discharge Forecast Modeling Project Quarterly Report April 1, 1987 to June 30, 1987. Borders, D.M.

The Discharge Forecast Modeling task is included in activities under Program Strategy Development for the Remedial Action Program (RAP) at Oak Ridge National Laboratory (ORNL). The objective of the task is to implement a computer-based simulation model to forecast surface-water runoff, associated contaminant concentrations within the White Oak Creek (WOC) watershed, and subsequent releases from White Oak Dam (WOD). This letter report is one in a series of quarterly progress reports.

63. ORNL/RAP/LTR-87/34, 16 pp. (1987, July 31), USGS Stream Discharge Monitoring in White Oak Creek Basin. Huff, D.D.

The USGS presently operates six stations in the White Oak Creek basin where stream stage data are collected at 15-minute observation intervals. Independent stage and flow rate measurements are used to develop a rating curve at each site. The rating curves are used to estimate flow rate at 15-minute intervals, and these results yield daily and monthly flow summaries. At one of the sites on White Oak Creek, a satellite data collection platform is in use to provide "real-time" data for flow forecast modeling.

64. ORNL/RAP/LTR-87/35, 44 pp. (1987, July 31), Geohydrologic Investigations at the OHF and 1513 Impoundments. Francis, C.W. and O.M. Sealand.

A site investigation assessing the geohydrologic characteristics at two waste impoundments formerly used to collect and dispose of liquid low-level radioactive wastes at Oak Ridge National Laboratory was conducted. The principal objective was to determine if leakage at these sites is in the form of fractured flow in the prevailing intermix of broken shale and limestone geologic media underlying the impoundments or possibly leakage along old waste lines and overflow lines rather than simple leakage through porous media. To examine these possibilities, a leak test using Sr-85 was conducted at the OHF impoundment and small diameter soil cores were taken along waste overflow lines at the 3513 impoundment. Strontium-85 added to the OHF impoundment rapidly disappeared from the filtered fraction of pondwater. For example, approximately 50% of the Sr-85 added to the impoundment had disappeared from the filtered pond water in a matter of 10 to 20 days. After 100 days, less than 10% of the Sr-85 was in the filtered phase. Loss of the Sr-85 was due to either (1) the sorption of Sr-85 on sediment (suspended of bottom) or (2) the direct leaching of Sr-85 out of the impoundment. Strontium-85 was detected in groundwater at only three monitoring wells down gradient from the impoundment. An inventory of Sr-85 in the pondwater and sediment 114 days after the addition of Sr-85 to the impoundment indicated that approximately one-third of the initial activity was associated with the sediment and less than 10% with the pondwater. A material balance on the quantity of Sr-85 added to the impoundment and that measured in the sediment and pondwater indicated that as much as 50 to 60% of the Sr-85 was lost from the impoundment by leaching to groundwater in a relatively short period of time, less than three months.

65. ORNL/RAP/LTR-87/36, 34 pp. (1987, July 31), Piezometer Sampling and Testing in the White Oak Creek Flood Plain. McCrackin, D.W., C.B. Sherwood, and N.D. Farrow.

As part of the ORNL Remedial Action Program, a network of approximately 60 shallow piezometer wells have been installed in the lower White Oak Creek (WOC) flood plain to aid in characterizing the shallow subsurface materials, the configuration of the water table, and the quality of the shallow groundwater. The piezometer installation program and well construction details have been summarized in ORNL/RAP/LTR-86/98 and ORNL/RAP/LTR-87/13.

The purpose of this report is to document the results of analysis of water in scoping samples collected from 27 piezometers and hydrologic conductivity tests in 38 piezometers in the lower flood plain.

66. ORNL/RAP/Sub-86/72139/1, 133 pp. (1987, March), Preliminary Geohydrologic Site Characterization and Proposed Water Quality Well Locations for WAG 4, WAG 5, WAG 3, and SWSA 1. Baughn, D.C.

This document recommends water quality well locations for Waste Area Groupings (WAGs) 4, 5 and 3 and Solid Waste Storage Area (SWSA) 1 at the Oak Ridge National Laboratory. The strategy for developing a proposed water quality well network included a review of available historical records, characterization of each site's environmental setting with particular regard to geology and hydrology and examination of the existing ground water transport pathways were estimated and fifty-three water quality well locations are recommended. Fifteen wells are proposed for WAG 4, twenty-two for WAG 5, fourteen for WAG 3 and two for SWSA 1. These wells will be used to gather preliminary water quality data for future site characterization studies.

67. ORNL/RAP/Sub-87/72140/2 (1987), Detailed Plugging and Abandonment Plans for Group I wells at the ORNL Hydrofracture Facilities. Texas World Operations, Inc.

This report presents detailed plugging and abandonment (P&A) plans for specific wells selected by Oak Ridge National Laboratory (ORNL) as representing a potentially significant environmental risk with regard to the spread of contaminated groundwater at ORNL. Previously, Texas World Operations, Inc. (TWO) prepared general plugging and abandonment plans for 153 wells at the ORNL site (TWO, 1987). From those 153 wells ORNL selected eleven wells, to be known as Group I wells for which specific P&A plans were to be written. These wells which include the four hydrofracture injection wells, six cased operation wells that have been breached and the Joy-1 well. The P&A plans presented in this report represent a more detailed P&A procedure than previously prepared. The plans include well history and address the following issues:
1. Conceptual plans for waste management, health and safety, decommissioning and decontamination of equipment and materials, and

quality assurance; 2. Impact on cost of plugging only one well, rather than all wells sequentially; 3. Impact on costs and schedules for implementing waste management, health and safety, decontaminating, and quality assurance activities; 4. Impact on costs resulting from inability to decontaminate and reuse tools and equipment; 5. Investigation of the feasibility of working over some wells without removal of surface structures; and 6. Identification of site modifications and access roads needed to implement the plugging and abandonment procedures. This report also describes the ORNL guidelines on which the P&A plans are based and the implementation of those guidelines, and identifies portions of the conceptual plans having major impact on costs or schedules or requiring specific exemption from existing ORNL standard policy.

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